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SECRET

CD/SA 54

Copy No. 54

Some Aspects of Shelter and Evacuation Policy to meet H-Bomb threat

1 Introduction

At the present time, with such air raid shelters as are at present in existence and allowing for the planned evacuation of the priority classes, the deaths from a single hydrogen bomb (assumed to have a power a thousand times that of the Nagasaki atomic bomb) on London would be nearly 2½ million, and from five bombs, one each on London, Birmingham, Liverpool, Manchester and Glasgow over 6 million. The first object of Civil Defence must be to prepare a scheme to reduce this figure. No attempt is made in this note to plan such a scheme, but the effect on casualties of certain arbitrary shelter and evacuation measures is discussed in order to indicate the order of magnitude of the reduction which a properly worked out scheme might be expected to achieve.

2 Method of Estimating Deaths

The deaths from a nominal atomic bomb among a population of standard density (43.56 per acre) all in houses have been estimated (CDJPS(EA)(48)14 (Revised)) as 31,000. This is equivalent to everyone within 0.6 miles of the bomb being killed and no one being killed outside this radius. If the generally accepted sealing laws for blast heat and gamma radiation are assumed to apply to hydrogen bombs, then it will be sufficiently accurate for present purposes if we assume that for them everyone is killed within a radius of $0.6\sqrt[3]{F}$ and no one is killed outside this radius. (Where F is the lower factor of the bomb expressed as a multiple of the lower of the nominal bomb). This assumption ignores the possibility that under certain circumstances there could be a large number of additional casualties due to fall out or radio-active crater debris.

From this and from the known night-time population distribution of our major cities (CD/SA 33), it is a simple matter to calculate the deaths from a bomb of any power on the centre of any particular city.

It must, however, be emphasised that the figures given in this note are deaths only. For the nominal atomic bomb it has usually been assumed that the injured are about equal in number to the killed. For the five hydrogen bombs considered in this note it is fairly certain that the killed would outnumber the injured due to the high population densities in the central (killed) areas as compared with the outer (injured) annuli. However, for the present, no attempt has been made to estimate the number of injured, but in considering the figures given in this note the existence of additional very large numbers of injured must be borne in mind.

3 Deaths with no shelter or evacuation

Table 1 shows the deaths that would result from a bomb with a power of 100N, 500N and 1000N on the centre of each of our five largest cities with no shelter or evacuation.

(N = 20 kt)

Table 1

Deaths with no evacuation and no shelter

City	Power of bombs		
	2 Mt	**10 Mt**	**20 Mt**
	100N	500N	1000N
London	830,000	2,420,000	3,340,000
Birmingham	500,000	1,070,000	1,360,000
Glasgow	780,000	1,180,000	1,330,000
Liverpool	590,000	1,080,000	1,280,000
Manchester	560,000	1,070,000	1,350,000
Total	3,260,000	6,820,000	8,660,000

It will be seen that deaths from the five 1000N bombs total over 8.6 million.

5 x 20 Mt)

4 Effect of Shelter on deaths

Detailed designs of shelters required to give protection at specified distances from hydrogen bombs of various size, particularly if burst at ground level, have not been worked out. However it is of some interest to see what reduction in deaths would result from shelters of specified performance, even though it is uncertain just what strength and thickness would be required to give that performance. The simplest way of specifying shelter performance is by means of the "Safety Rating" concept developed in CD/SA 48. The safety rating of a shelter was there defined as the saving in life, expressed as a percentage of the deaths without shelter, resulting from the use of the shelter in an area of uniform population density. This shelter with a safety rating of 80 would save 80% of the lives that would have been lost if everyone had been in a house. Put in another way, shelter with a safety rating of 80 would reduce the area within which deaths occurred to one fifth of that for people in houses, and therefore the radius of death to $\frac{1}{\sqrt{5}}$. For a bomb with a power factor of F the equivalent radius of death if everyone is in a shelter with a safety rating of 80 will therefore be $\frac{0.6\sqrt[3]{F}}{\sqrt{5}}$. Similarly for shelter with a safety rating of 90 the radius will be $\frac{0.6\sqrt[3]{F}}{\sqrt{10}}$.

Although, as stated above, the design details of shelters to give these safety ratings have not been determined, it seems probable that surface or trench shelters of rather less than Grade A strength (say 1000 lb/sq.ft.) would be required to give a safety rating of 80, and that a strength of about 2000 lb/sq.ft. would be required for a safety rating of 90. For small street surface shelters the extra cost of an increase in strength of this sort is very small (e.g. the structural cost of a 12"/1000 lb/sq.ft. design is given in CD/SA 48 as £15.2 per person, based on seated capacity) and of a 12"/1400 lb/sq.ft. design as £15.5 per person) and detailed studies may well show that shelters with a higher safety rating than 90 are a practical proposition.

From the formulae for equivalent radii of death given above, and from the population distribution given in CD/SA 33 we can calculate the expected deaths in these two types of shelter under the same conditions of attack as were given in Table 1 for a population all in houses. The results are given in Tables 2 and 3.

Table 2

Deaths with no evacuation but with everyone in a shelter with a Safety Rating of 80

City	Power of bomb 2 Mt 100N	 10 Mt 500N	 20 Mt 1000N
London	135,000	474,000	785,000
Birmingham	129,000	353,000	484,000
Glasgow	223,000	576,000	760,000
Liverpool	159,000	401,000	565,000
Manchester	117,000	386,000	540,000
Total	763,000	2,190,000	3,134,000

(N = 20 kt)

Table 3

Deaths with no evacuation but with everyone in a shelter with a Safety Rating of 90

City	Power of bomb 2 Mt 100N	 10 Mt 500N	 20 Mt 1000N
London	59,000	216,000	367,000
Birmingham	64,000	191,000	296,000
Glasgow	115,000	327,000	489,000
Liverpool	78,000	238,000	340,000
Manchester	49,000	186,000	315,000
Total	365,000	1,158,000	1,807,000

The considerations discussed above strongly suggest that the right policy against the hydrogen bomb would be to evacuate the central areas of our larger cities and to provide shelter where it is most useful, i.e. in the annulus surrounding the central evacuation area.

In the meantime, however, it is of some interest to examine the effect on casualties of an arbitrary evacuation area of radius 5 miles in the case of London and 3 miles in the case of Birmingham, Glasgow, Liverpool and Manchester, in conjunction with shelter having a safety rating of 80 and 90 in the surrounding annulus. In each case the evacuees from the central area are assumed to be accommodated in the surrounding annulus, arbitrarily taken as between 5 and 15 miles in the case of London and between 3 and 7 miles in the case of the other four cities. The factors by which this evacuation would increase the population density in the 'reception' annulus are as follows; London 1.5, Birmingham 1.6, Glasgow 2.5, Liverpool 1.9 and Manchester 1.7. The deaths resulting from an attack with 1000N bombs after this scheme had been implemented are shewn in Tables 4 and 5.

Table 4

Deaths from 1000N bombs after evacuation of 5 mile radius circle for London and 3 mile radius for other cities. Evacuees assumed accommodated in surrounding annulus where they and the original inhabitants are provided with shelter having a safety rating of 80.

20 Mt

City	Position of bomb		
	Central	2 miles from centre	In position to cause maximum deaths
London	0	0	518,000
Birmingham	0	159,000	256,000
Glasgow	0	171,000	247,000
Liverpool	0	174,000	247,000
Manchester	0	164,000	257,000
Total	0	668,000	1,525,000

Table 5

Deaths from 1000N bombs after evacuation of 5 mile radius circle for London and 3 mile radius for other cities. Evacuees assumed accommodated in surrounding annulus where they and the original inhabitants are provided with shelter with a safety rating of 90.

20 Mt

City	Position of bomb		
	Central	2 miles from centre	In position to cause maximum deaths
London	0	0	261,000
Birmingham	0	56,000	155,000
Glasgow	0	64,000	152,000
Liverpool	0	67,000	152,000
Manchester	0	62,000	151,000
Total	0	249,000	871,000

It will be seen from Tables 4 and 5 that, with this scheme of total evacuation of a central area and shelter in the surrounding annulus, a central bomb causes no deaths at all. Clearly, however, the enemy would be aware of our provisions and might well choose to drop his bombs where they would cause maximum casualties. On average, and without allowing for local concentrations which would be bound to occur in the "reception annulus", this would be at about 7 miles from the centre in the case of London and about 4 miles for the other cities. The average deaths from bombs in these worst positions are therefore given in Tables 4 and 5. Comparing these figures with those to Table 1 it will be seen that evacuation plus shelter with a safety rating of 80 has reduced deaths by 82%, and plus shelter with a safety rating of 90 by 90%.

Conclusion

Without shelter or evacuation, the deaths from an attack with only five hydrogen bombs might total over $8\frac{1}{2}$ million. The primary object of Civil Defence must be to reduce this figure. Neither evacuation alone nor shelter alone could reduce these deaths to a manageable proportion, but with a suitable combination of the two, consisting of the total evacuation of the population of the central areas into the surrounding annuli where shelter would be provided, it should be possible to reduce the maximum deaths from this particular attack to something of the order of one million.

April, 1954.

E.L.W. **E. L. W. = Edward Leader-Williams**

OSA.41/4/32. **(who in WWII tested the Morrison shelter while John Fleetwood Baker's colleague)**

REFERENCES:

CD/SA 48 = Nat. Archives HO 225/48, "The safety-cost relationship for certain types of surface and trench shelters"

CD/SA 72 = Nat. Archives HO 225/72, "Casualty estimates for ground burst 10 megaton bombs"

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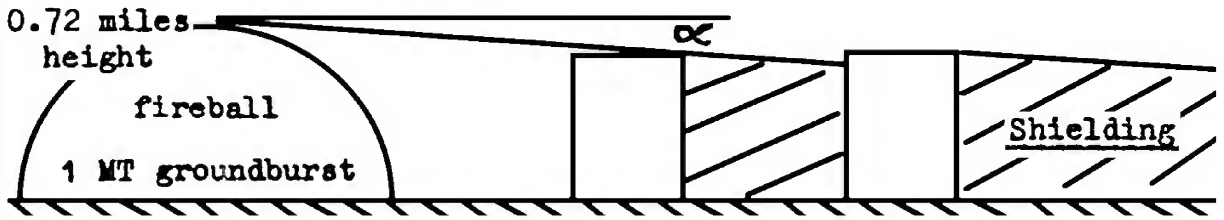
(Paper at Tripartite Thermal Effects Symposium, Dorking, October 1964)

IGNITION AND FIRE SPREAD IN URBAN AREAS FOLLOWING A NUCLEAR ATTACK

G. R. Stanbury

INITIAL FIRE INCIDENCE



Thermal pulse precedes the blast wave

Assuming that buildings on opposite sides of a street which is receiving heat radiation from a direction perpendicular to its length are of the same height we take the average depth of a floor to be 10 ft.

Effect of Shielding: Estimation of the number of exposed floors

Distance from explosion miles	Angle of arrival α^{o}	Width of street (units of 10 ft.)						
		2	3	4	5	6	7	8
3	$13\frac{1}{2}$	.5	.5	1	1	1.5	1.5	2
4	10	.5	.5	.5	1	1	1.5	1.5
5	8	.5	.5	.5	.5	1	1	1

SPREAD OF FIRE

From last war experience of mass fire raids in Germany it was concluded that the overall spread factor was about 2; i.e. about twice as many buildings were destroyed by fire as were actually set alight by incendiary bombs

Number of fires started per square mile in the fire-storm raid on Hamburg, 27th/28th July, 1943

102 tons H.E.	48 tons, 4 lb. magnesium	40 tons, 30 lb. gel.
100 fires	27,000 bombs	3,000 bombs
	8,000 on buildings	900 on buildings
	1,600 fires	800 fires

2,500 fires in 6,000 buildings

However, the important thing to note is that the total number of fires started in each square mile (2,500) was nearly half that of the total number of buildings; in other words, almost every other building was set on fire

When the figure of 1 in 2 for the German fire storms is compared with the figures for initial fire incidence of ∼ 1 in 15 to 30 obtained in the Birmingham and Liverpool studies it can only be concluded that a nuclear explosion could not possibly produce a fire storm.

SECONDARY FIRES FROM BLAST DAMAGE IN LONDON

Fire situation from 1,499 fly bombs in the built-up part of the London Region

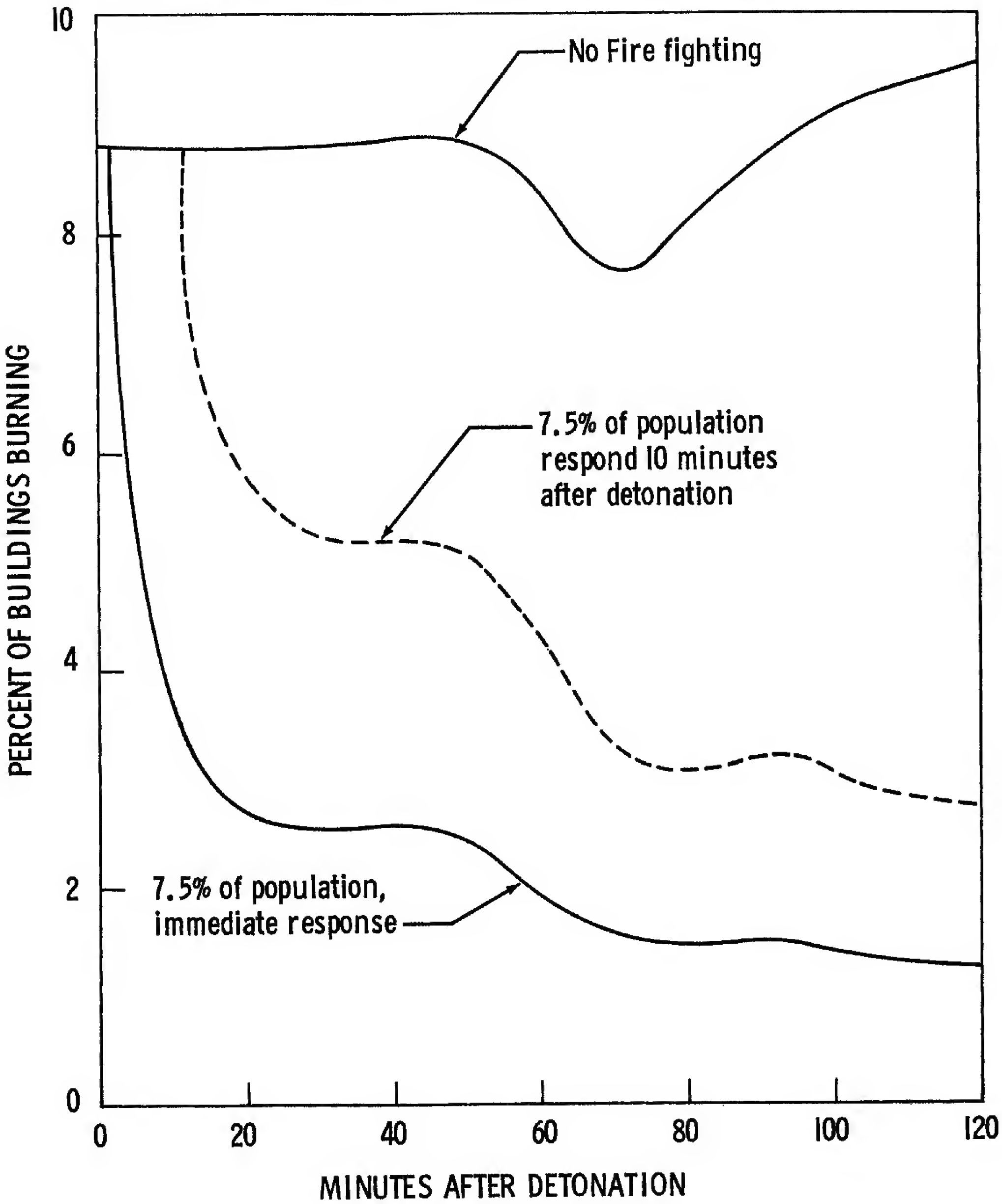
(Fires from 1 ton TNT V1 cruise missiles, 1944)

	Number of fly bombs	Fly Bombs Caused				
		No fire	Small fire	Medium fire	Serious fire	Major fire
Grand Totals	1,499	804	609	75	7	4

The large proportion started no fires at all even in the most heavily built-up areas.

All these fly bombs fell in the summer months of 1944 which were unusually dry. In winter in this country in residential areas there are many open fires which may provide extra sources of ignition. The domestic occupancy is a low fire risk however, and as the proportion of such property in the important City and West End areas is small this should not introduce any serious error. Moreover, in winter, the high atmospheric humidity and the correspondingly high moisture content of timber would tend to retard or even prevent the growth of fire.

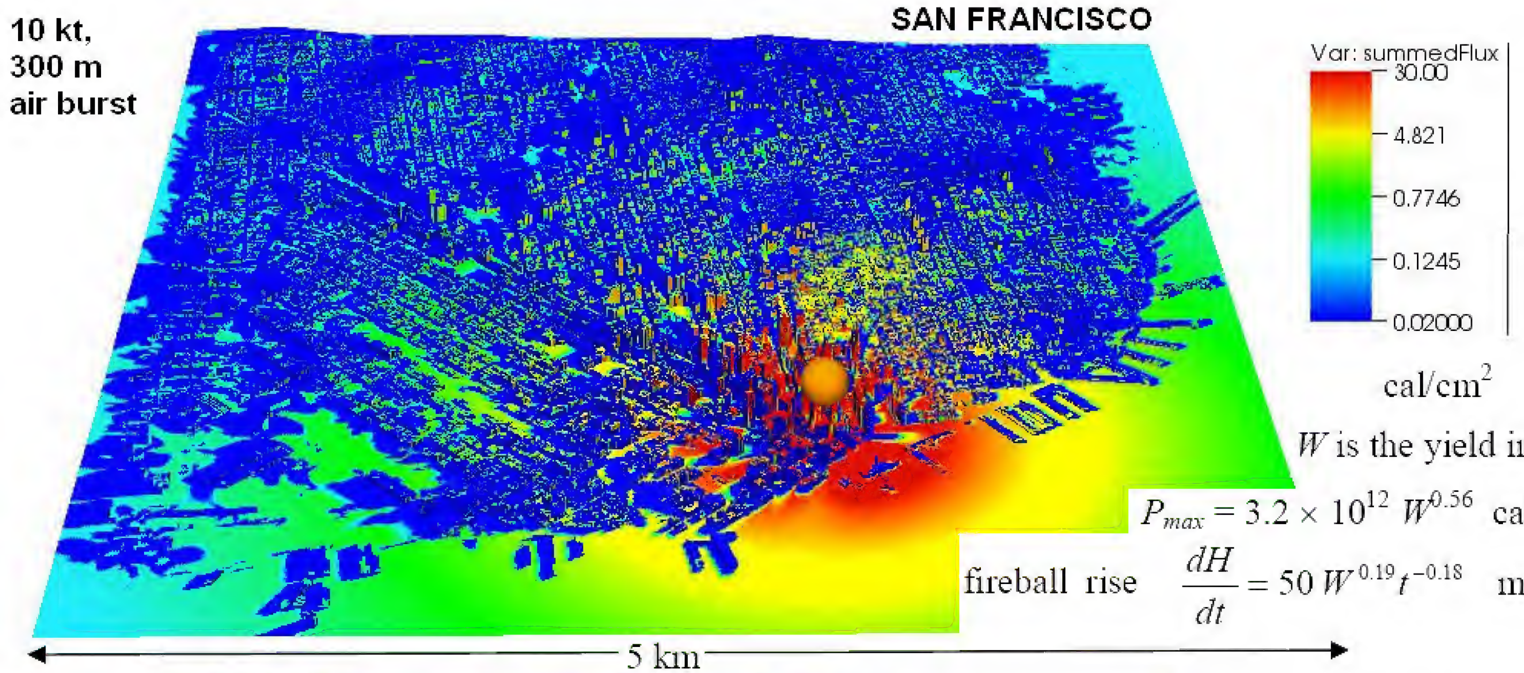
Takata, A.N., Mathematical Modeling of Fire Defenses, IITRI, March 1970, AD 705 388.



Thermal Radiation from Nuclear Detonations in Urban Environments

R. E. Marrs, W. C. Moss, and B. Whitlock
Lawrence Livermore National Laboratory

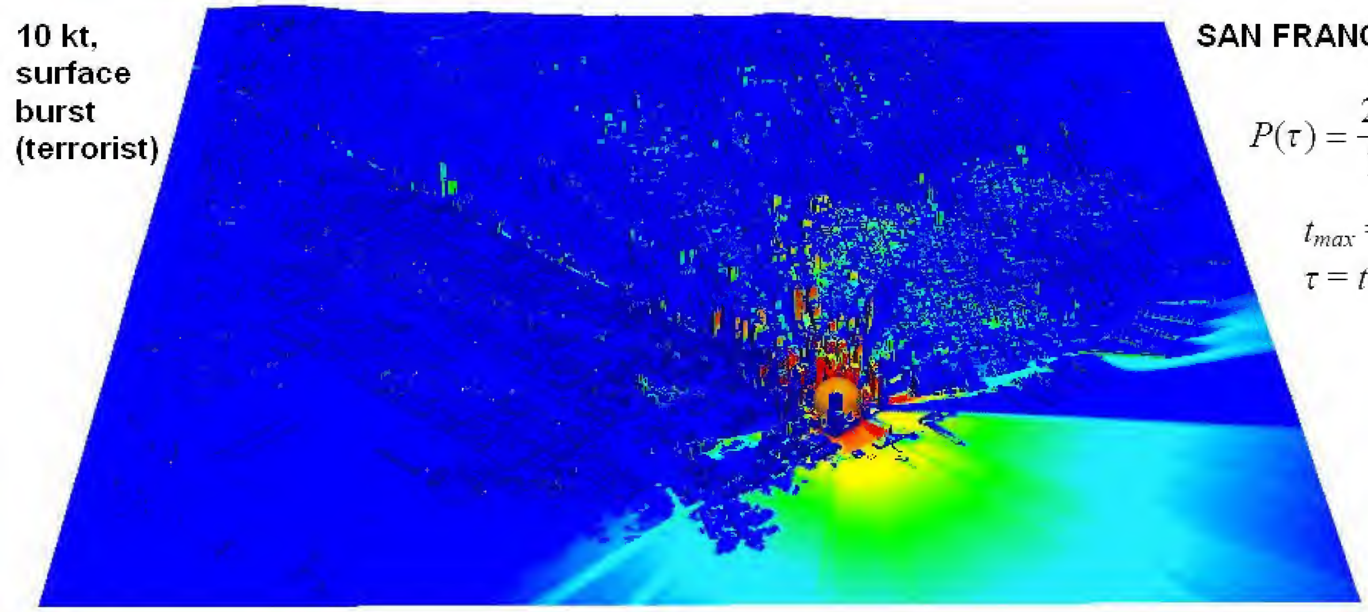
UCRL-TR-231593
June 7, 2007



W is the yield in kt

$$P_{max} = 3.2 \times 10^{12}\ W^{0.56}\ \text{cal/s}$$

fireball rise $$\frac{dH}{dt} = 50\ W^{0.19} t^{-0.18}\ \text{m/s}$$



$$P(\tau) = \frac{2.85(\tau + 0.5)^{-2}}{1 + e^{-(\tau - 0.8)/0.15}}$$

$$t_{max} = 0.04\ W^{0.44}\ \text{s}$$

$$\tau = t / t_{max}$$

Even without shadowing, the location of most of the urban population within buildings causes a substantial reduction in casualties compared to the unshielded estimates. Other investigators have estimated that the reduction in burn injuries may be greater than 90% due to shadowing and the indoor location of most of the population [6].

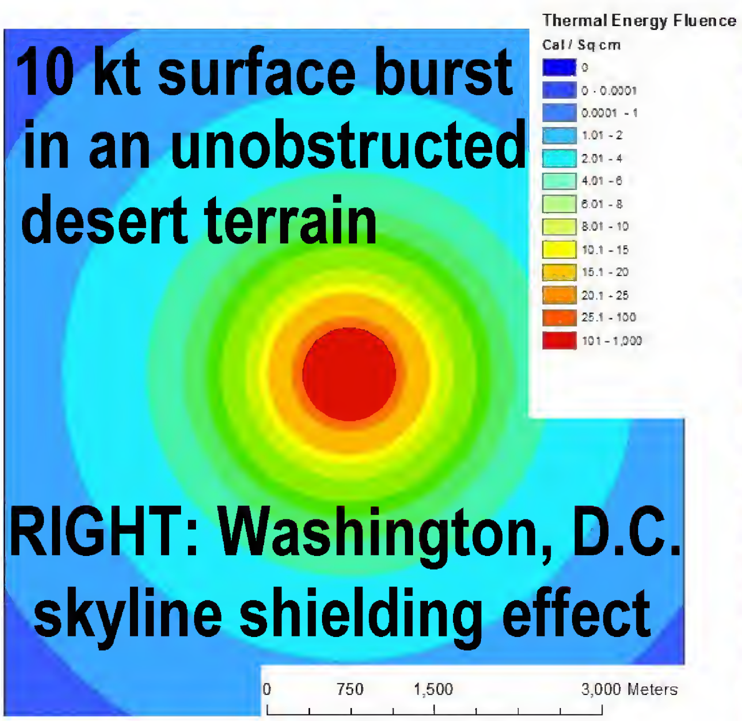
We have shown that common estimates of weapon effects that calculate a "radius" for thermal radiation are clearly misleading for surface bursts in urban environments. In many cases only a few unshadowed vertical surfaces, a small fraction of the area within a thermal damage radius, receive the expected heat flux.

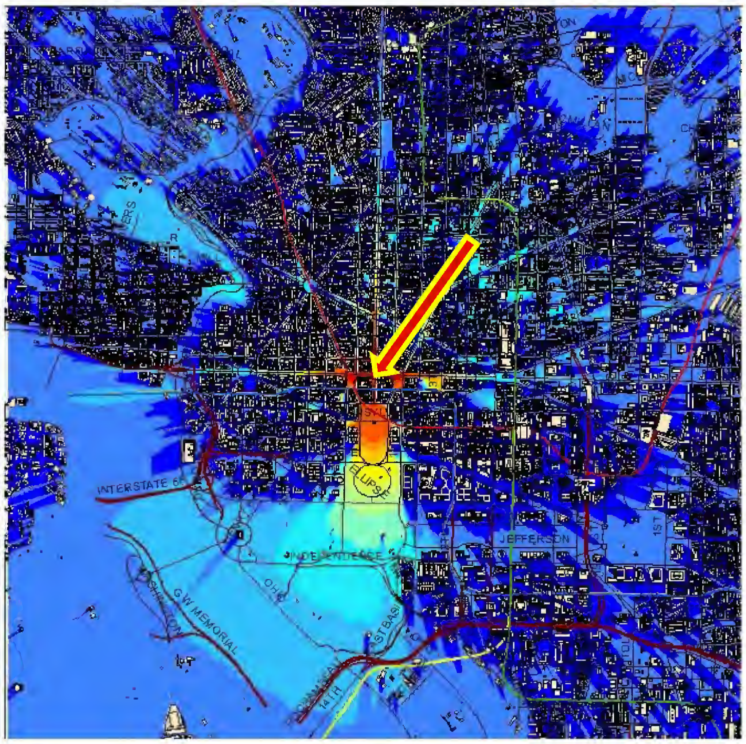
Modeling the Effects of Nuclear Weapons in an Urban Setting

Radiation Countermeasures Symposium
An AFRRI 50th Anniversary Event

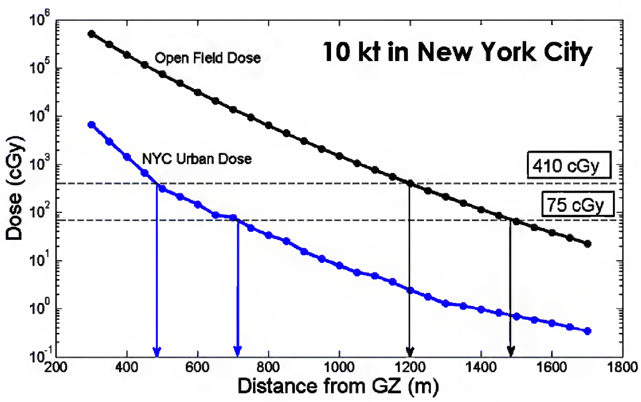
Kyle Millage, CHP, PE
Applied Research Associates, Inc.

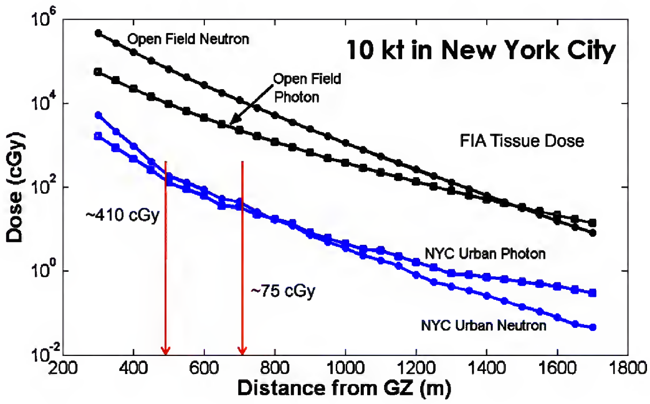
15 June 2011

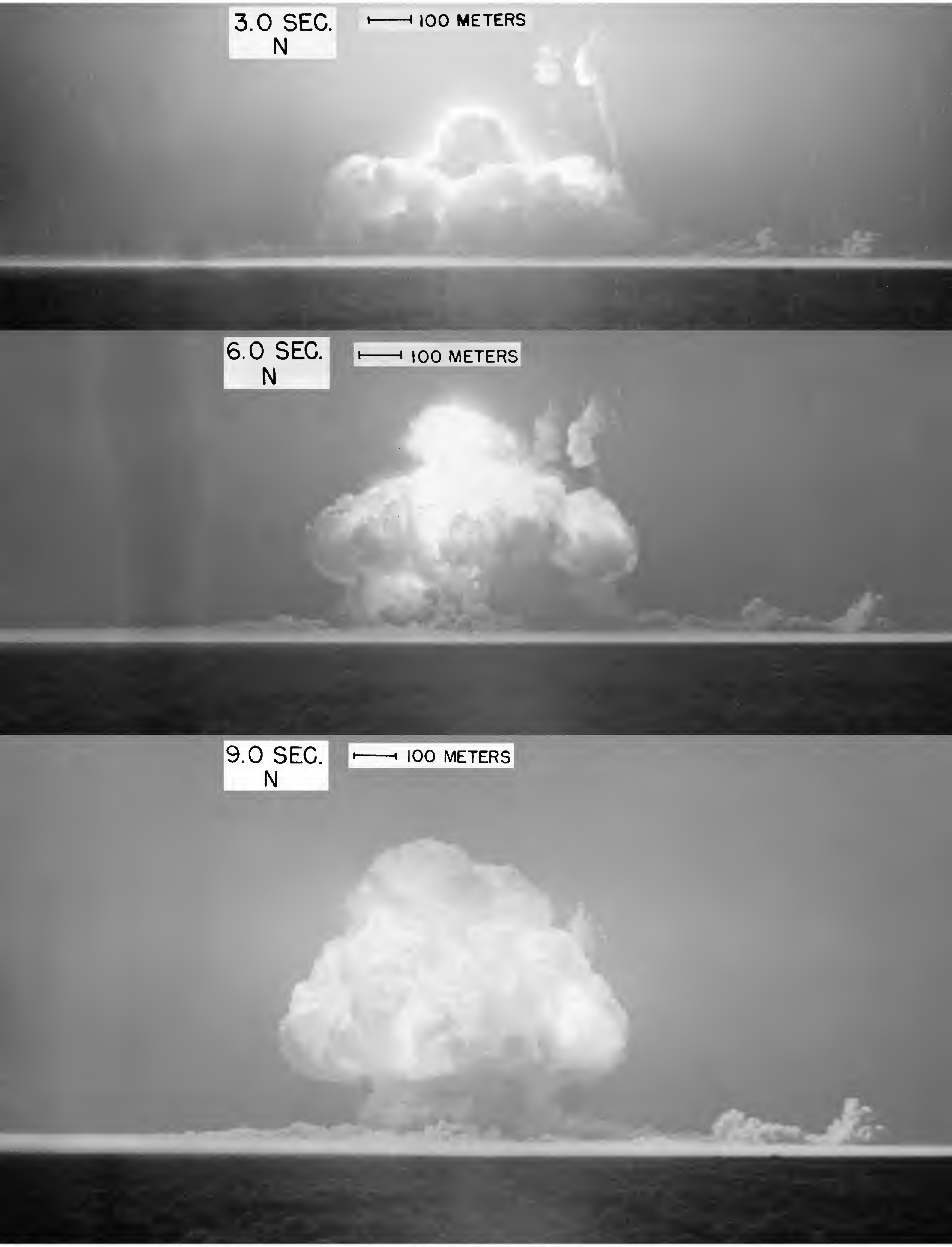




- Classic prompt circles of blast, thermal and radiation environments in an open field will significantly over-estimate the effects in an urban setting

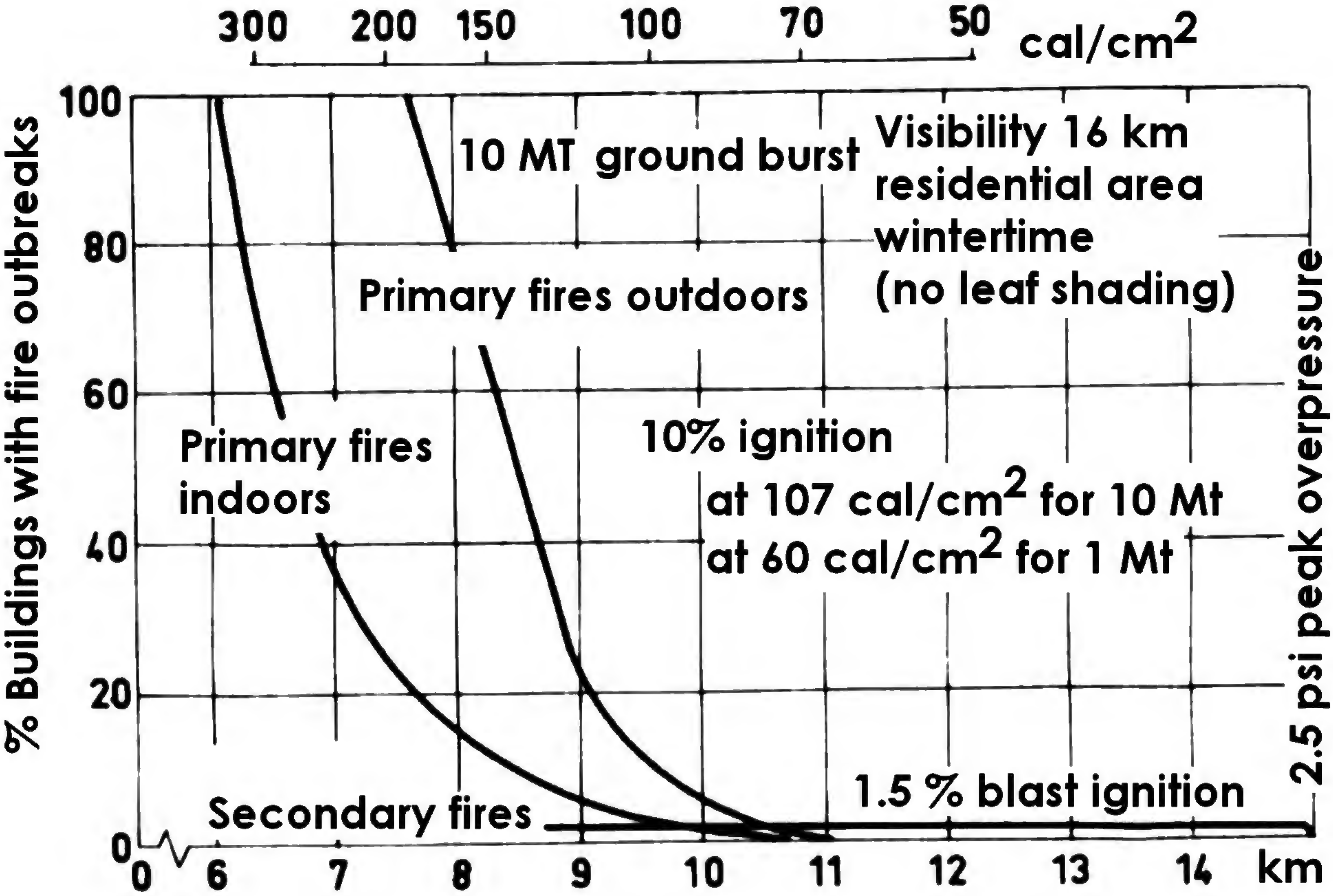


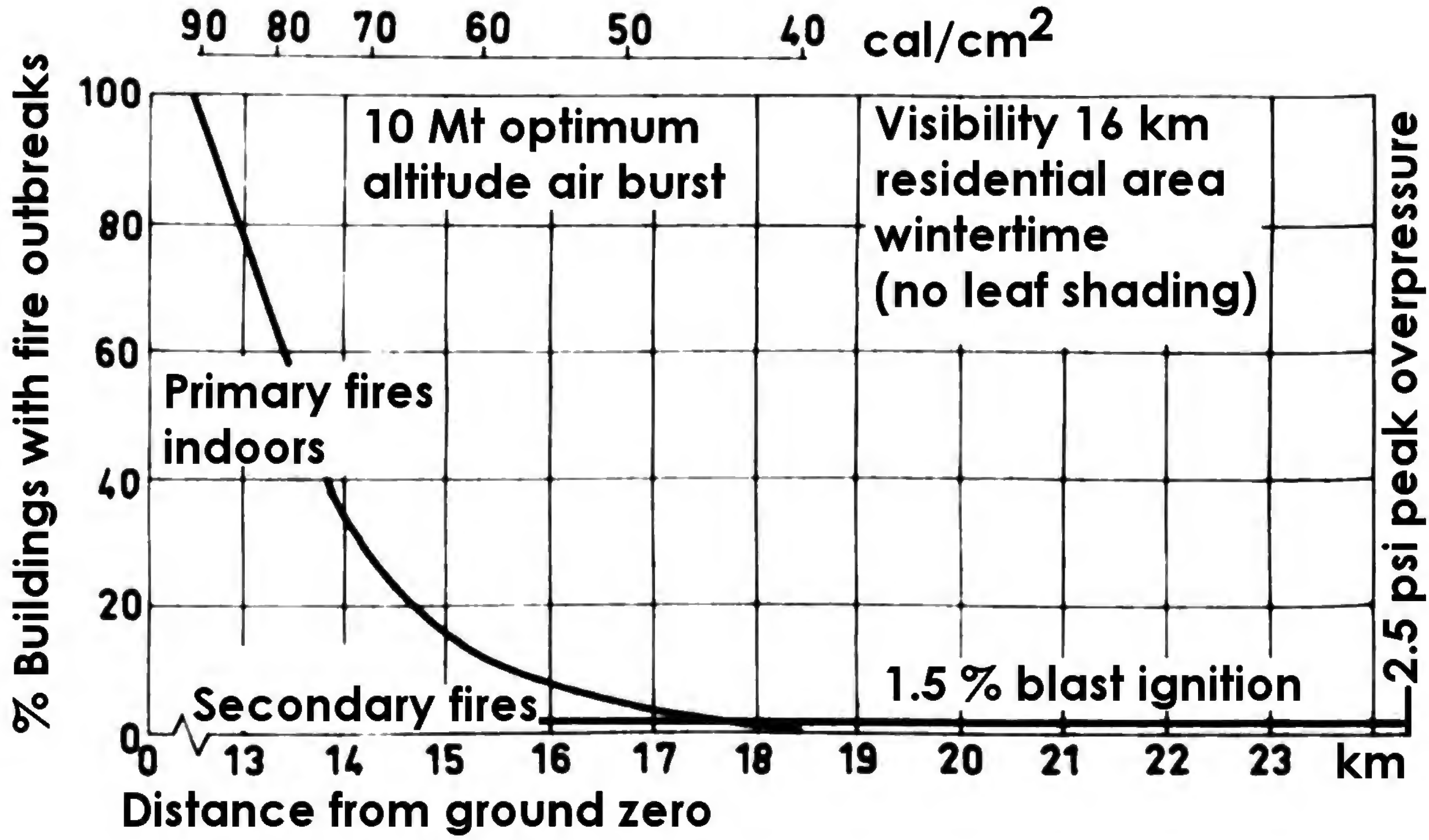


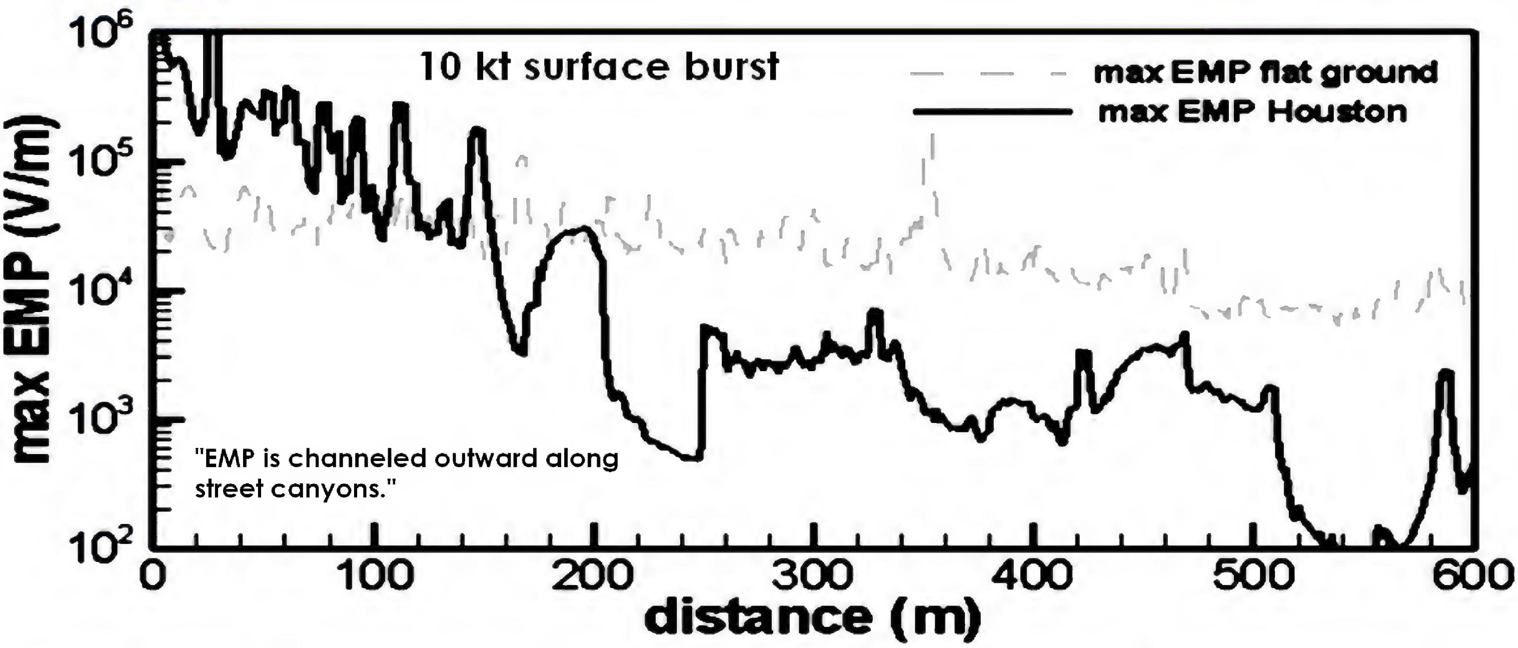


TRINITY (19 kilotons, 100 feet burst altitude, New Mexico, 16 July 1945). Note the very slow rate of fireball rise.

John L. Crain, et al., Supplemental Analysis - Civil Defense Rescue, Stanford Research Institute, AD0625802, 1965.





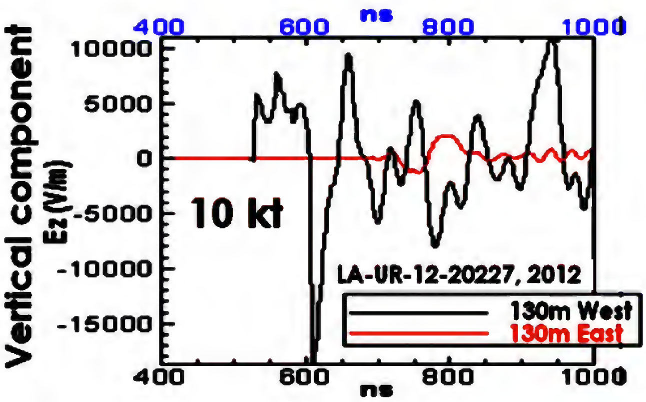


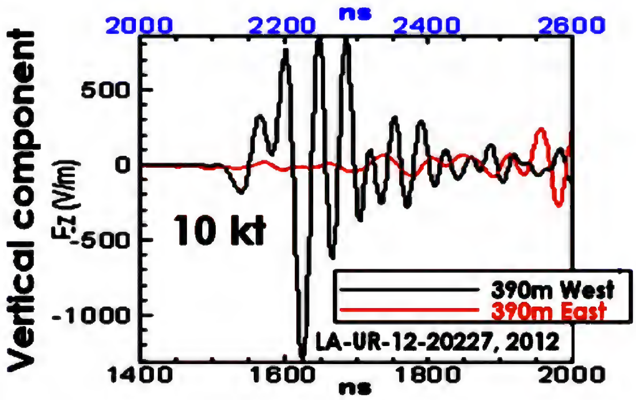
Effects of buildings on maximum EMP from a generic "Fatman" type bomb in downtown Houston, Texas

Tall buildings (1) attenuate horizontal prompt gamma rays, (2) attenuate the line-of-sight (UHF) EMP frequencies

Scott Smith, Jeff Bull, Trevor Wilcox, Randy Bos, Xuan-Min Shao, Tim Goorley, Keeley Costigan

Nuclear EMP simulation for large-scale urban environments, Los Alamos LA-UR-12-24078, August 2012





3rd October, 1963.

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SCIENTIFIC ADVISER'S BRANCH

CD/SA 116

RESEARCH ON BLAST EFFECTS IN TUNNELS

With Special Reference to the Use of London Tubes as Shelter

by F. H. Pavry

Summary and Conclusions

The use of the London tube railways as shelter from nuclear weapons raises many problems, and considerable discussion of some aspects has taken place from time to time. But - until the results of the research here described were available - no one was able to say with any certainty whether the tubes would provide relatively safe shelter or not.

The more recent research here described showed for the first time that a person sheltering in a tube would be exposed to a blast pressure only about $\frac{1}{3}$ as great as he would be exposed to if he was above ground. (In addition, of course, he would be fully protected from fallout in the tube.)

Large-Scale Field Test ($^1/_{40}$) at Suffield, Alberta

The test is fully described in an A.W.R.E. report(6). The decision of the Canadian Defence Research Board to explode very large amounts of high explosive provided a medium for a variety of target-response trials that was welcome at a time when nuclear tests in Australia were suspended. A.W.R.E. used the 100-ton explosion in 1961 to test, among other items, the model length of the London tube, at $^1/_{40}$th scale, that had already been tested at $^1/_{117}$ scale.

Blast Entry from Stations

There was remarkable agreement with the $^1/_{117}$th scale trials: "maximum overpressure in the train tunnels was of the order of $\frac{1}{3}$rd the corresponding peak shock overpressure in the incident blast. The pressures in the stations were about $^1/_6$th those in the corresponding incident blast .... ".

(6) $^1/_{40}$th Scale Experiment to Assess the Effect of Nuclear Blast on the London Underground System. A.W.R.E. Report E2/62. (Official Use Only.)

Tunnel shelters in hillside, very close to ground zero in Nagasaki, protected the occupants from blast, thermal radiation, and immediate nuclear radiation.

100 ton TNT test on 1000 ft section of London Underground tube at Suffield, Alberta, 3 Aug 1961

Atomic Weapons Research Establishment, "1/40th Scale Experiment to Assess the Effect of Nuclear Blast on the London Underground System", Report AWRE-E2/62, 1962, Figure 30. (National Archives ES 3/57.)

200 FT FROM GROUND ZERO	400 FT FROM GROUND ZERO
100 PSI OUTSIDE	20 PSI OUTSIDE
30 PSI IN TUBES	7.2 PSI IN TUBES
15 PSI IN TUBE STATIONS	4.3 PSI IN TUBE STATIONS

Aldwych Underground tube station as Blitz shelter, 8 October 1940

Aldwych tube London 21 Oct 1940: effective Blitz air raid shelter

THOSE WHO WENT TO SHELTERS began a new kind of night-life. Some took over the Tubes, camping out in this fashion—Elephant and Castle Station, 11th November, 1940.

ADA038738

Secondary Fires

Secondary fires are those that result from airblast damage. Their causes include overturned gas appliances, broken gas lines, and electrical short-circuits. McAuliffe and Moll (Reference 1) studied secondary fires resulting from the atomic attacks on Hiroshima and Nagasaki and compared their results with data from conventional bombings, explosive disasters, earthquakes, and tornadoes. Their major conclusion was that secondary ignitions occur with an overall average frequency of 0.006 for each 1000 square feet of floor space, provided airblast peak overpressure is at least 2 psi. The frequency of secondary ignitions appears to be relatively insensitive to higher overpressures.

Based on surveys of Hiroshima and Nagasaki buildings.

FREQUENCY OF SECONDARY IGNITIONS AS A FUNCTION OF BUILDING TYPE

Type of Structure	Frequency of Secondary Ignitions (for each 1,000 square feet of floor area)
Wood	0.019
Brick	0.017
Steel	0.004
Concrete	0.002

MULTIPLYING FACTOR FOR TYPES OF BUILDING OCCUPANCIES

Type of Occupancy	Multiplying Factor
Public	0.4
Mercantile	0.5
Residential	0.5
Manufacturing	1.0
Miscellaneous	10.0

MULTIPLYING FACTOR FOR TIME OF DAY

Time of Day	Multiplying Factor
Night	0.5
Day (other than mealtimes)	1.0
Mealtimes	2.0

1 . Secondary Ignitions in Nuclear Attack, J. McAuliffe and K. Moll, Stanford Research Institute, Menlo Park, California 94025, SRI Project 5106 (AD 625173), July 1965.

OFFICE OF THE AIR SURGEON

NP-3041

MEDICAL EFFECTS OF ATOMIC BOMBS

The Report of the Joint Commission for the Investigation of the Effects of the Atomic Bomb in Japan; Volume VI

By

Ashley W. Oughterson
George V. LeRoy
Averill A. Liebow
E. Cuyler Hammond
Henry L. Barnett
Jack D. Rosenbaum
B. Aubrey Schneider

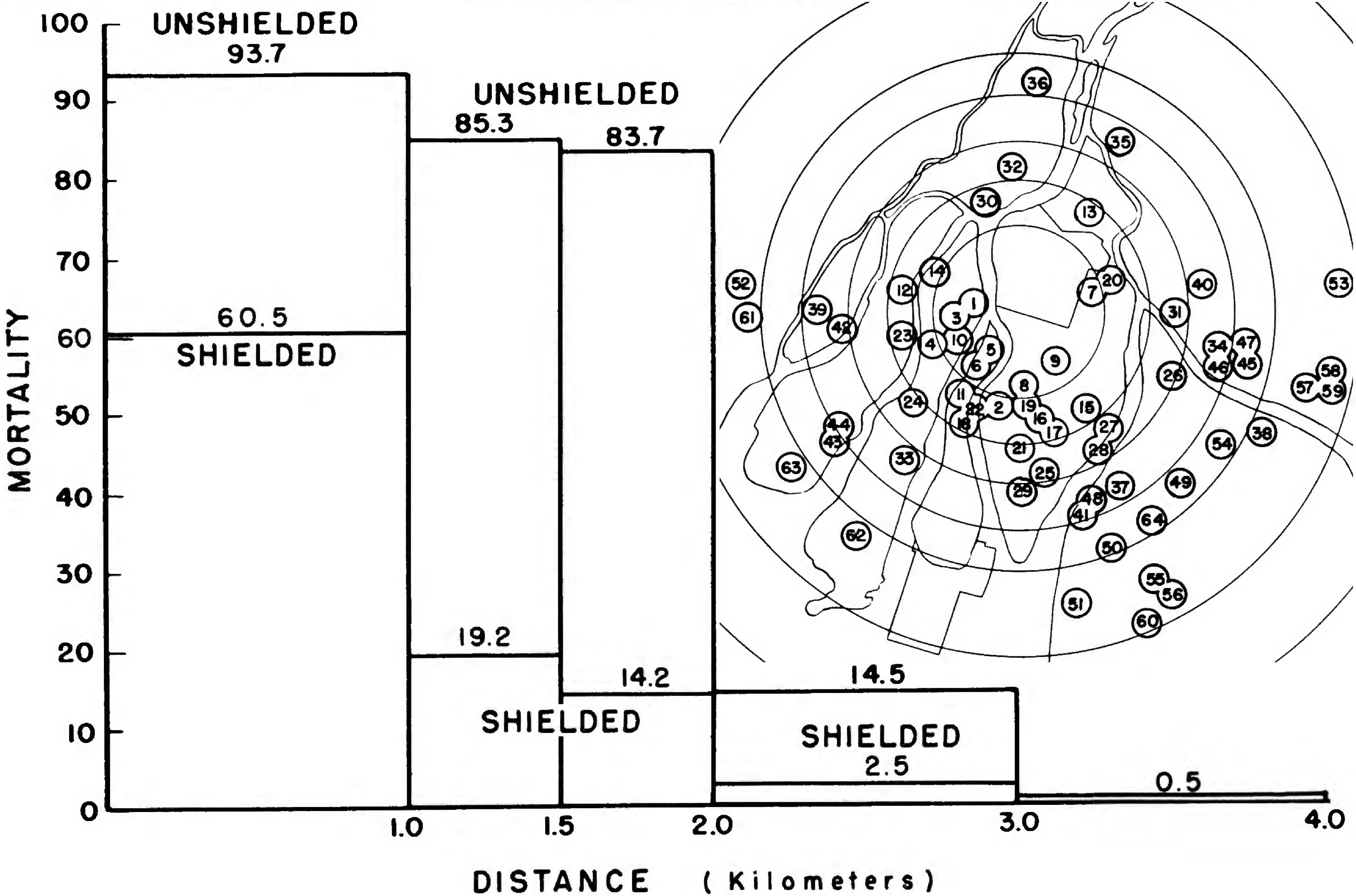
July 6, 1951
[TIS Issuance Date]

Army Institute of Pathology

UNITED STATES ATOMIC ENERGY COMMISSION
Technical Information Service, Oak Ridge, Tennessee

HIROSHIMA SCHOOL CHILDREN

WORK PARTIES DISTRIBUTION



(US Strategic Bombing Survey, 1946 report "Effects of the Atomic Bombs on Hiroshima and Nagasaki", page 16)

***PROTECTION AGAINST RADIANT HEAT.** This patient (photographed by Japanese 2 October 1945) was about 6,500 feet from ground zero when the rays struck him from the left. His cap was sufficient to protect the top of his head against flash burns.* HIROSHIMA

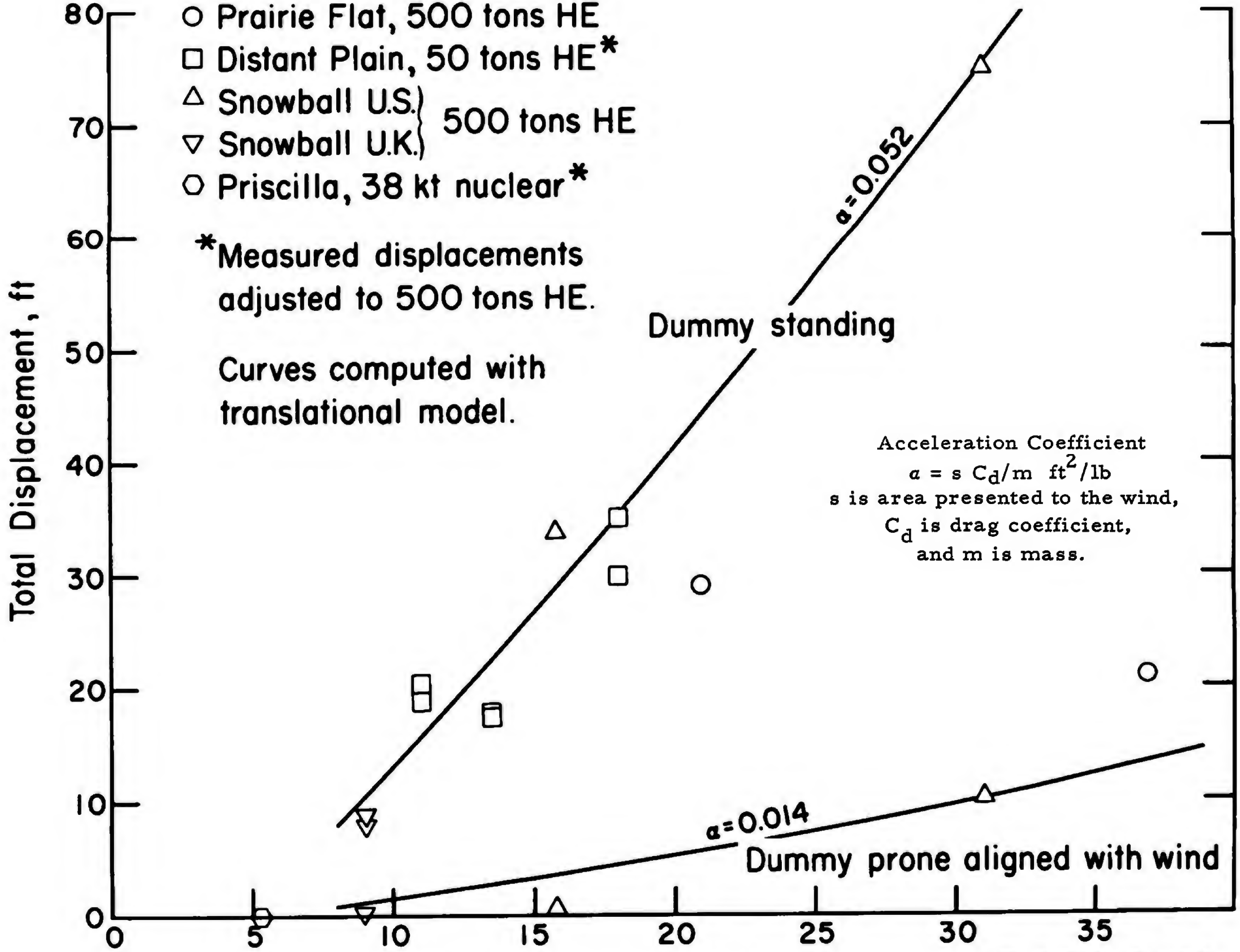
(Lethal 6.7 cal/sq cm, according to the 1979 US Office of Technology Assessment "Effects of Nuclear War")

1 HB–8
The house at Main and Elm Streets. Two typical colonial two-story center hall frame dwellings were placed at 3,500 and 7,500 feet from the bomb tower. (FCDA—Operation Doorstep—Yucca Flat, Nev., Mar. 17, 1953.)

X–19
This mannequin can only stay in the position in which he was placed, staring through the window at coming disaster. A real occupant of this house could prepare—and survive. (FCDA—Operation Doorstep—Yucca Flat, Nev., Mar. 17, 1953.)

1 HA–11
House No. 1, from the camera tower from which the dramatic collapse pictures were taken. The Post Office truck to the left, although it lost all windows and suffered body damage, was driven away later, as was the car in the rear of the house. Entry to the basement was made through the corner at lower center. (FCDA—Operation Doorstep—Yucca Flat, Nev., Mar. 17, 1953.)

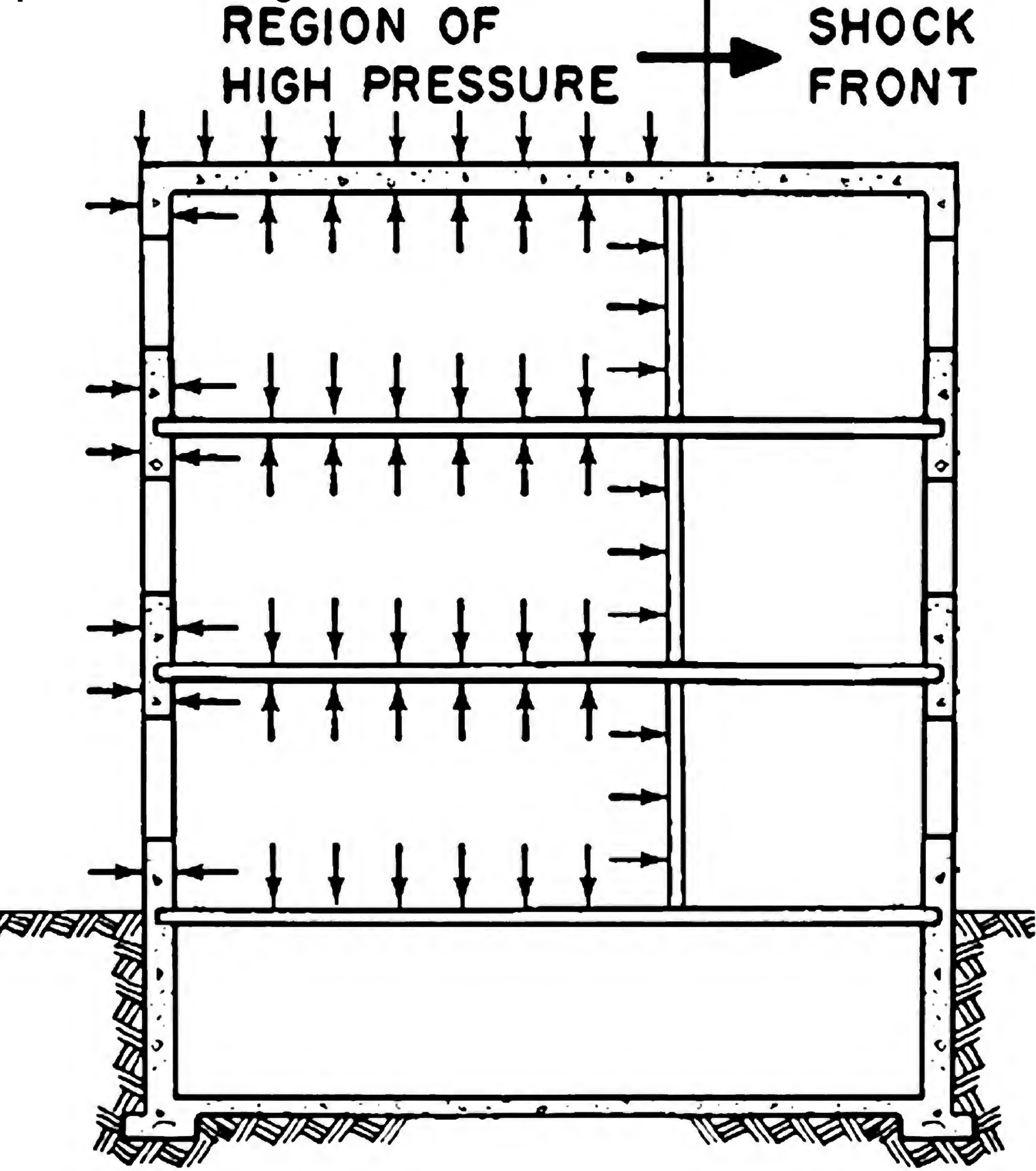
LSA–2
3,500 feet from ground zero. The house overhead is totally destroyed, some of it has fallen into the basement, but the mannequin in the lean-to shelter is undisturbed. The photo was taken from ground level, looking into the basement through the gap between the basement wall and the broken floor timbers. (FCDA—Operation Doorstep—Yucca Flat, Nev., Mar. 17, 1953.)

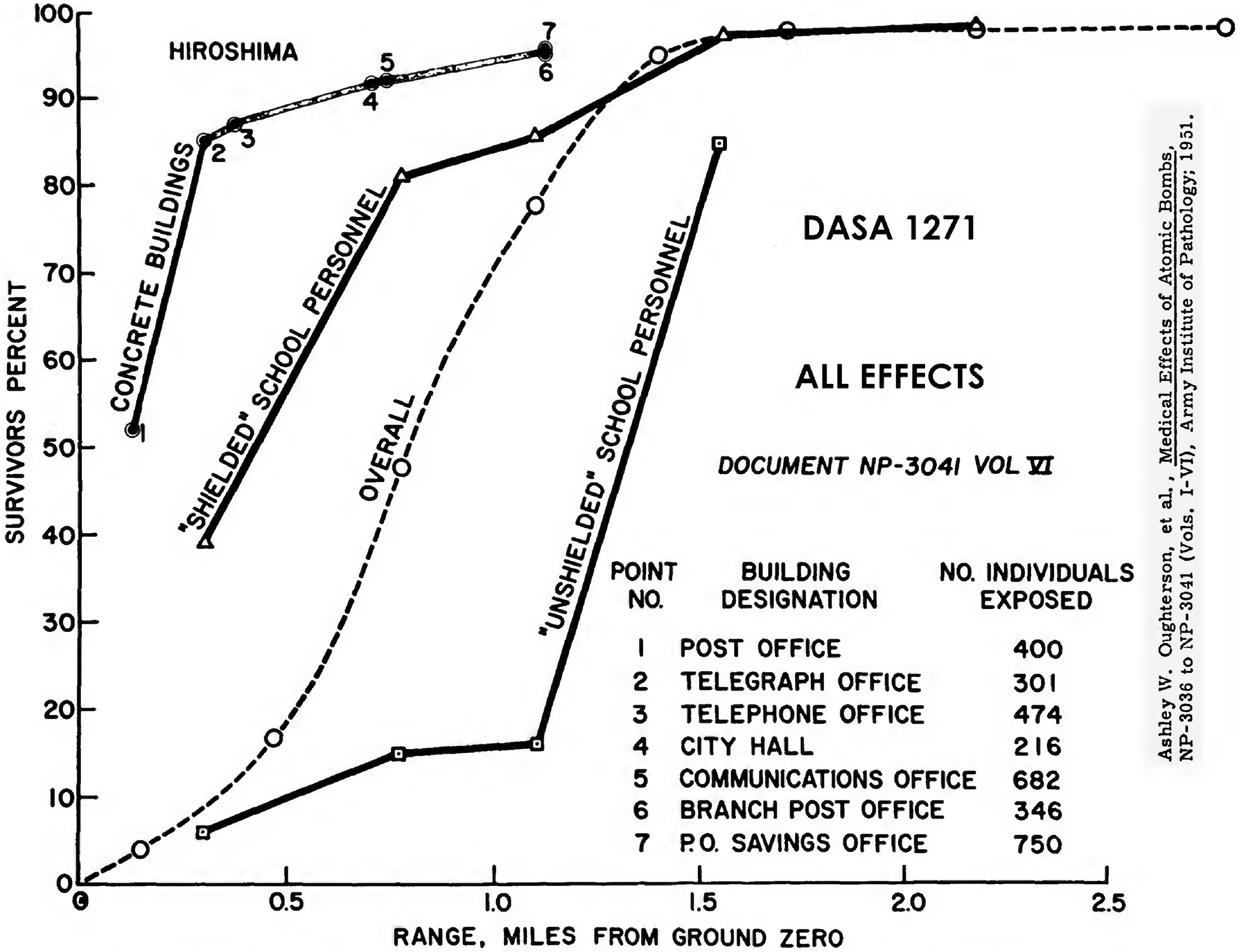


80
70
60
50
40
30
20
10
0
Total Displacement, ft
0
5
10
15
20
25
30
35
Peak Overpressure, psi
○ Prairie Flat, 500 tons HE
□ Distant Plain, 50 tons HE*
△ Snowball U.S.
▽ Snowball U.K.
500 tons HE
⬡ Priscilla, 38 kt nuclear*
*Measured displacements adjusted to 500 tons HE.
Curves computed with translational model.
α=0.052
Dummy standing
α=0.014
Dummy prone aligned with wind
Acceleration Coefficient
α = s Cd/m ft²/lb
s is area presented to the wind,
Cd is drag coefficient,
and m is mass.

DASA 2710

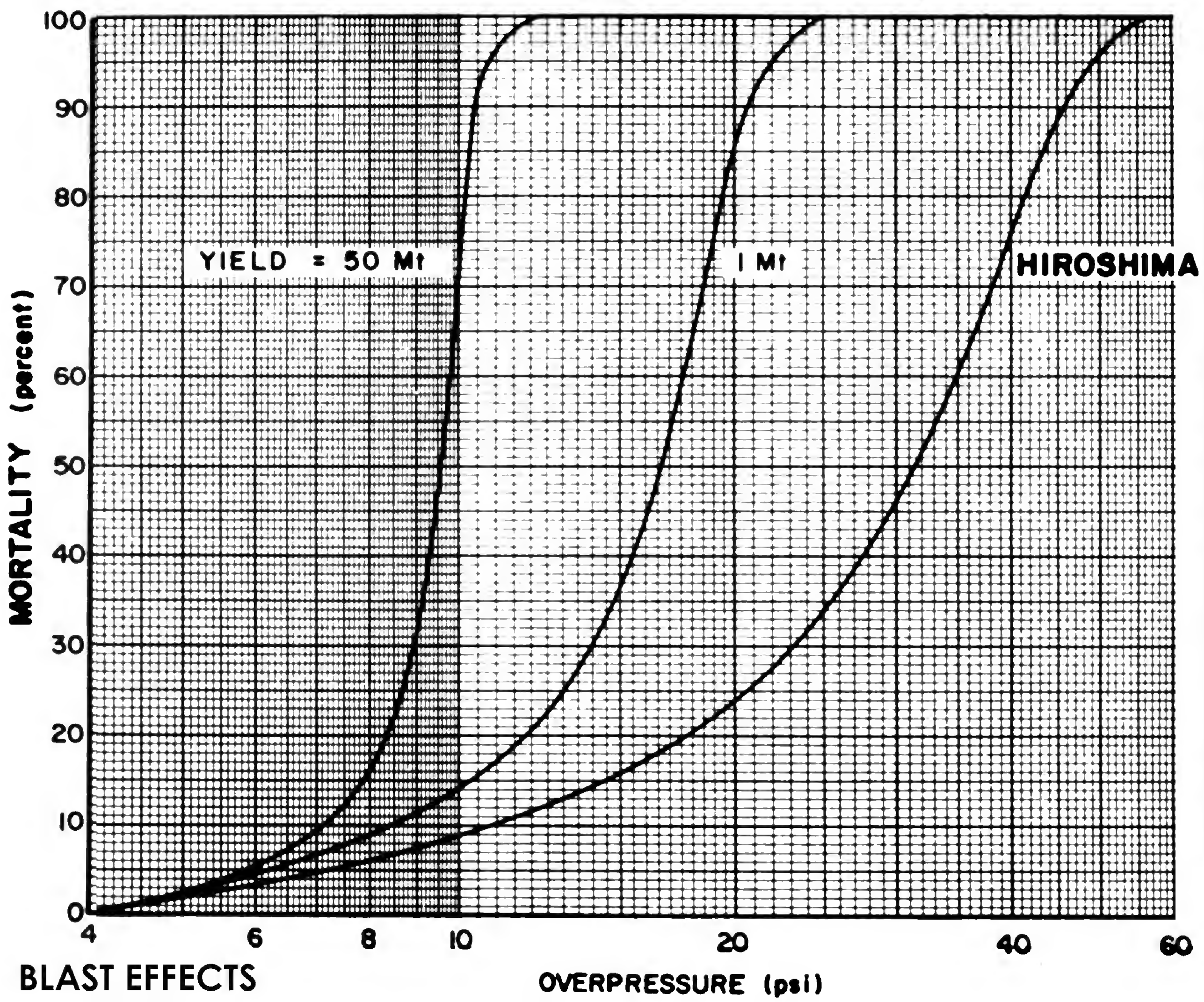
Rapid equalization of inside and outside pressure for large window areas





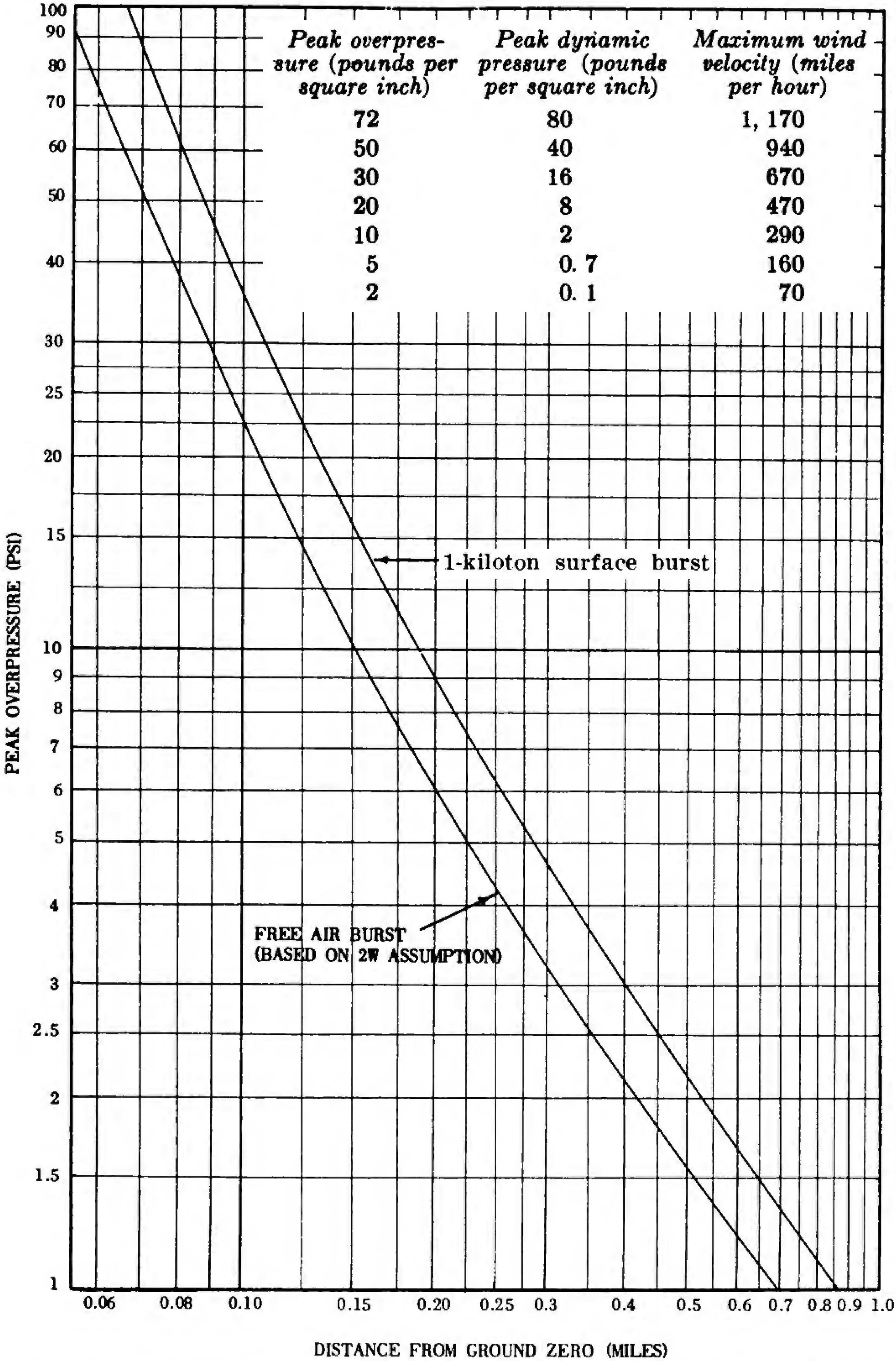
Ashley W. Oughterson, et al., Medical Effects of Atomic Bombs, NP-3036 to NP-3041 (Vols. I-VI), Army Institute of Pathology; 1951.

DC-P-1060 **NONSEISMIC REINFORCED-CONCRETE BUILDINGS**



L. Wayne Davis, Donald L. Summers, William L. Baker, and James A. Keller, Prediction of Urban Casualties and the Medical Load from a High-Yield Nuclear Burst, DC-FR-1060, The Dikewood Corporation

BLAST EFFECTS

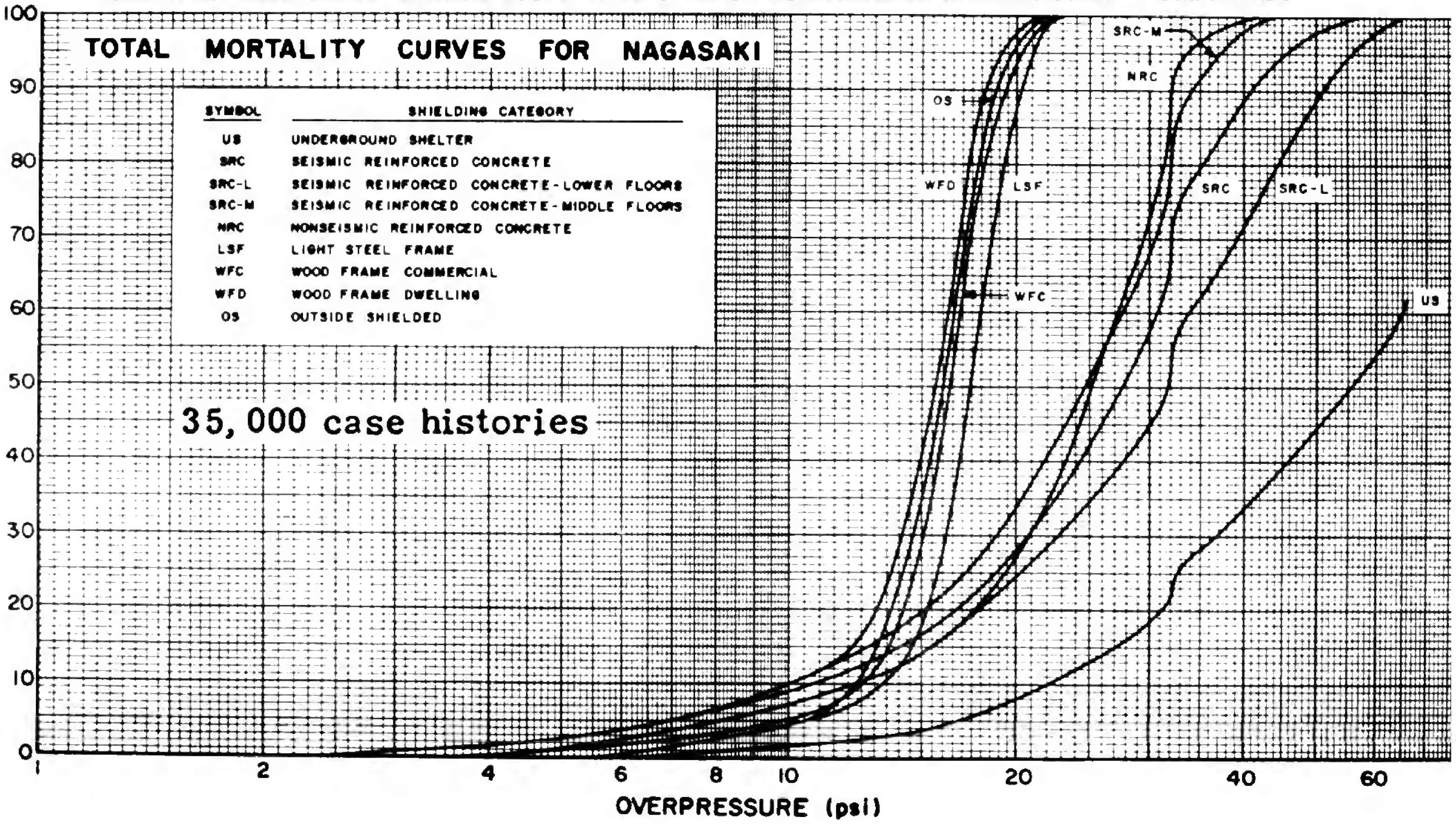


Peak overpressure (pounds per square inch)	*Peak dynamic pressure (pounds per square inch)*	*Maximum wind velocity (miles per hour)*
72	80	1, 170
50	40	940
30	16	670
20	8	470
10	2	290
5	0. 7	160
2	0. 1	70

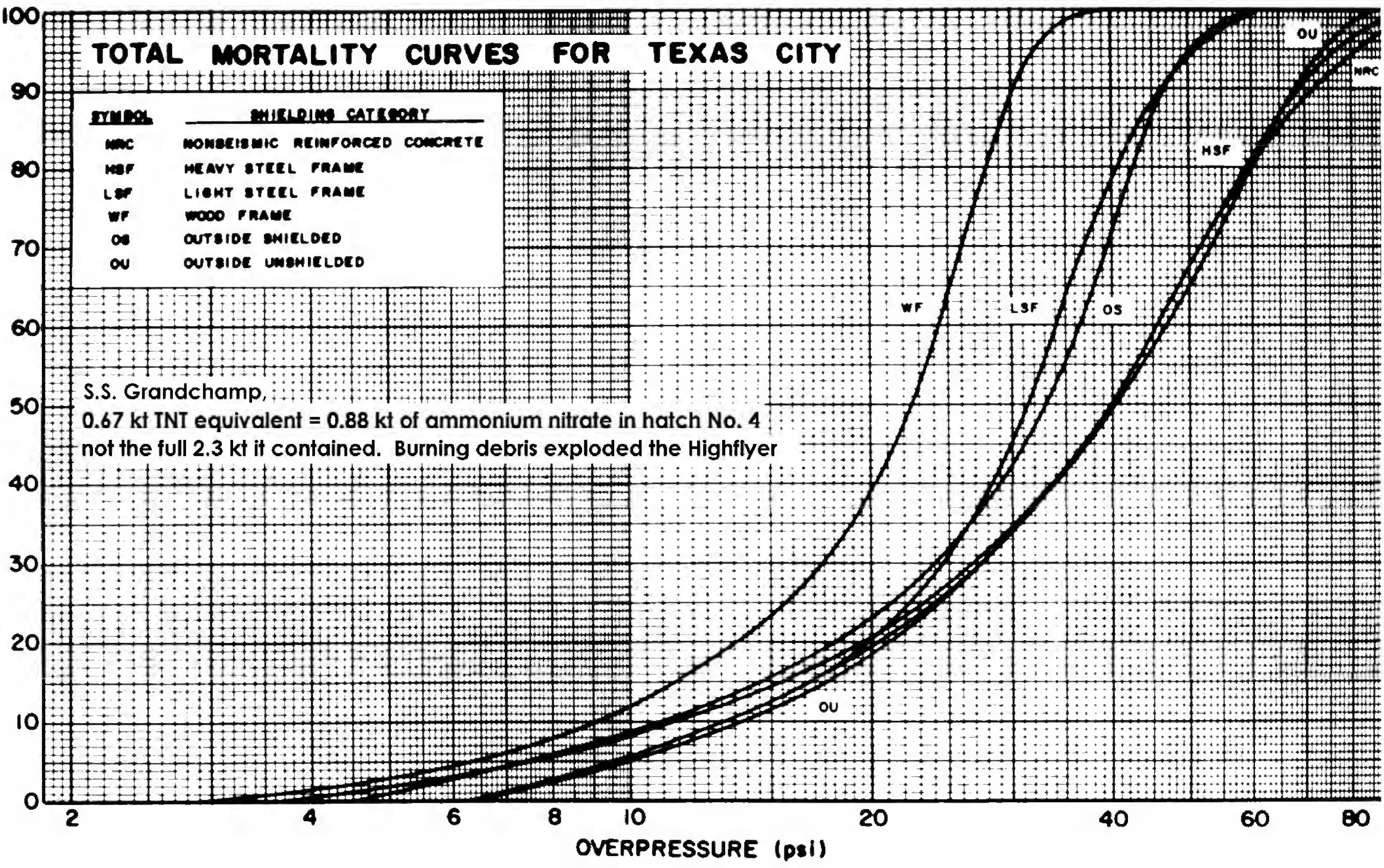
Scaling. For yields other than 1 KT, the range to which a given overpressure extends scales as the cube root of the yield

L. Wayne Davis, Donald L. Summers, William L. Baker, and James A. Keller, Prediction of Urban Casualties and the Medical Load from a High-Yield Nuclear Burst, DC-FR-1060, The Dikewood Corporation

For people in or shielded by structures in Japan, the blast and initial-nuclear radiation were the dominant immediate effects.

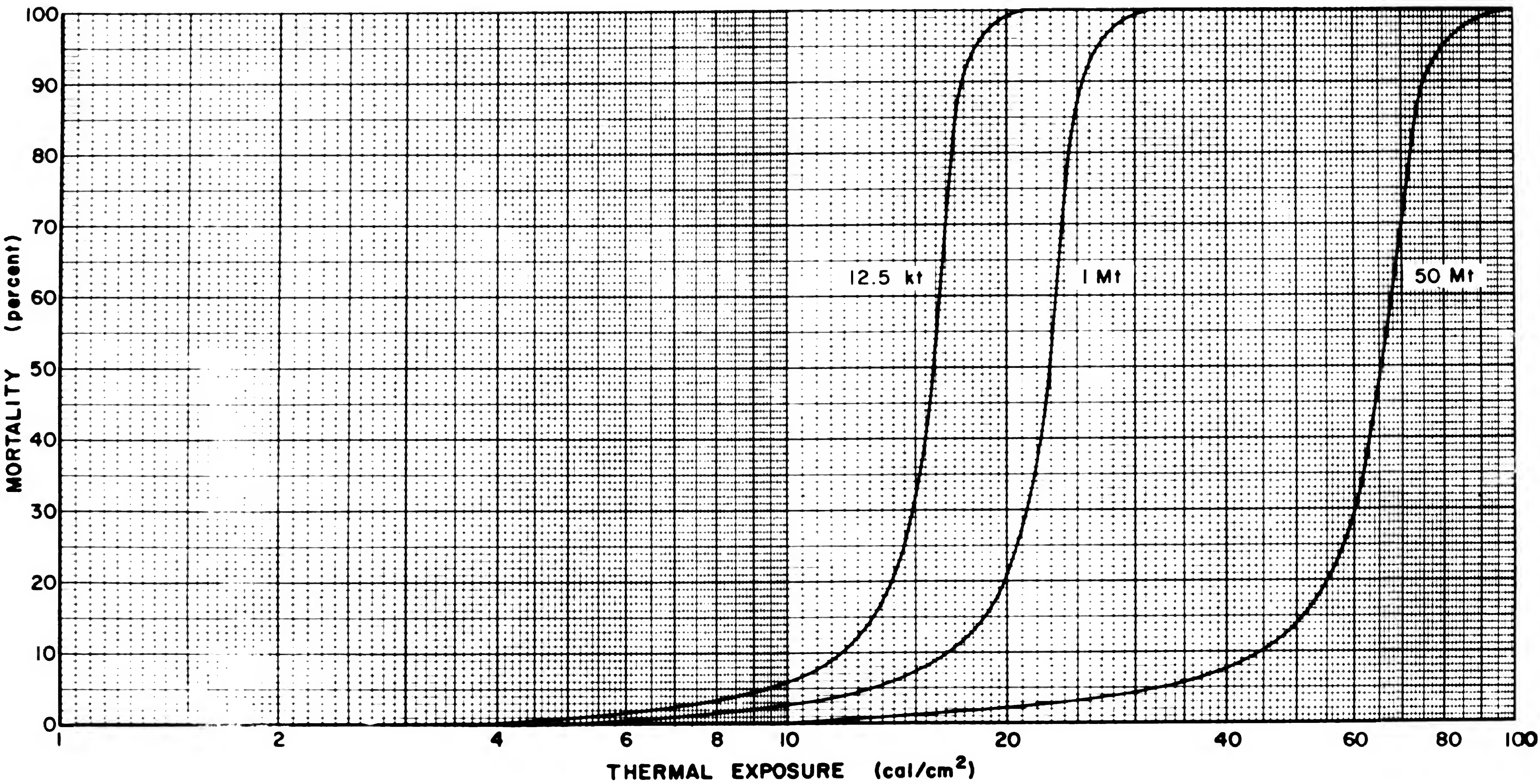


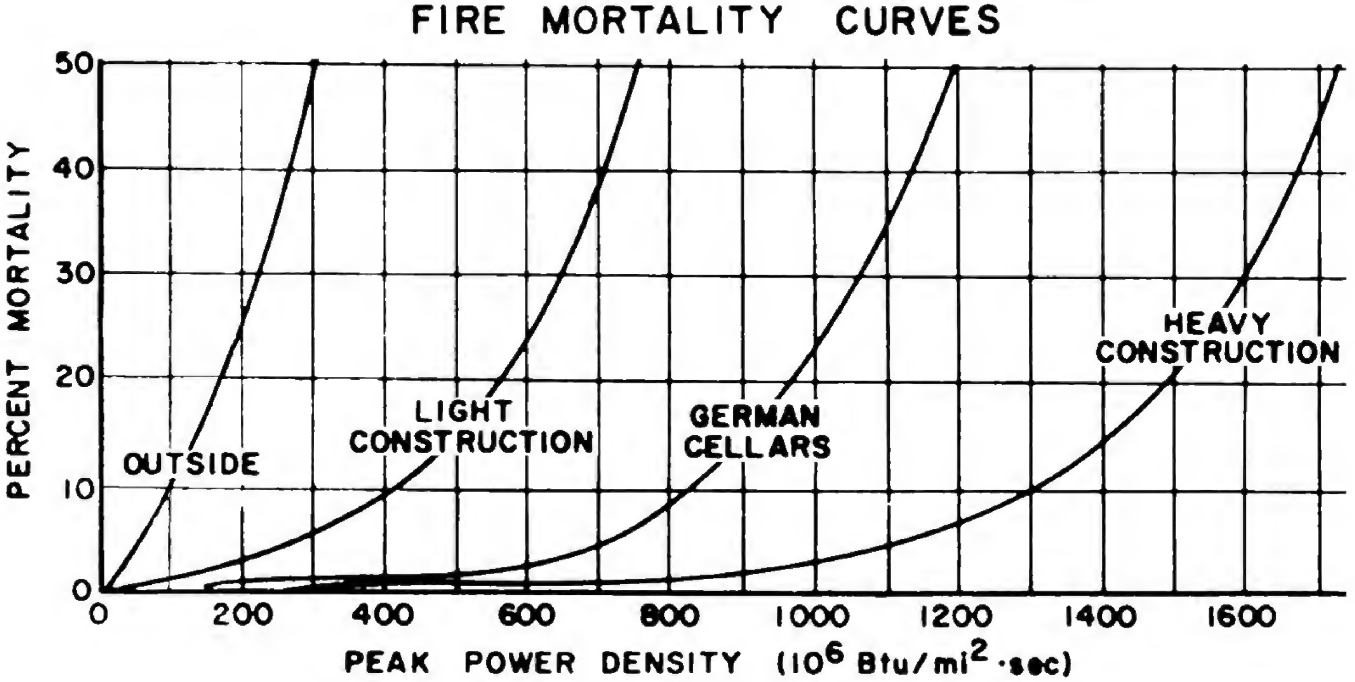
S.S. Grandchamp at Texas City exploded in 1947. It contained 2.3 kt of ammonium nitrate in 100-lb paper bags, but only the 0.88 kt in No. 4 hatch was tamped and exploded after catching fire. TNT equivalent was 0.67 kt.

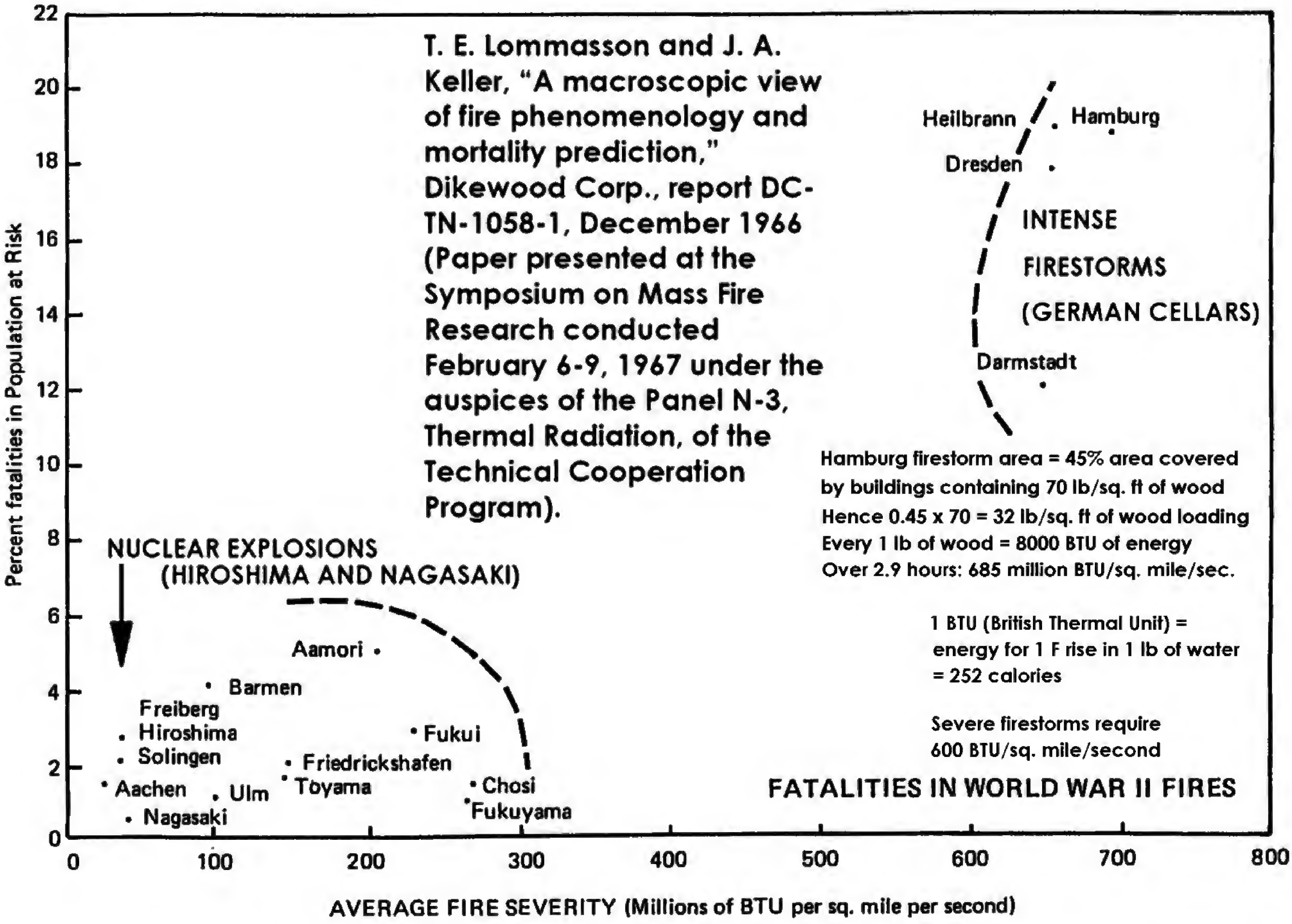


PROMPT-THERMAL MORTALITY CURVES FROM SURFACE BURSTS FOR OUTSIDE-UNSHIELDED PERSONS

[Data based on Hiroshima assuming 12.5 kt yield. For the 2002 revised 16 kt yield in DS02, thermal exposures must be increased by 28%]







Lommasson and Keller, **A Macroscopic View of Fire Phenomenology and Mortality Predictions**, Dikewood Corporation, DC-TN-1058-1, December 1966.

J. A. Keller, A Study of World War II German Fire Fatalities, DC-TN-1050-3, The Dikewood Corporation; April, 1966.

R. Schubert, Examination of Building Density and Fire Loading in the Districts Eimsbuettel and Hammerbrook of the City of Hamburg in the Year 1943 (20 volumes, in German), Stanford Research Institute; January, 1966.

When water evaporates from the burned surface, cooling results and the body loses heat. The larger the burn wound, the more water loss and the more heat or energy loss.

How Can the Fluid and Heat Losses Be Diminished?

Think Plastic Wrap as Wound Dressing for Thermal Burns

ACEP (American College of Emergency Physicians) News
http://www.acep.org/content.aspx?id=40462

August 2008
By Patrice Wendling
Elsevier Global Medical News

CHICAGO - Ordinary household plastic wrap makes an excellent, biologically safe wound dressing for patients with thermal burns en route to the emergency department or burn unit.

The Burn Treatment Center at the University of Iowa Hospitals and Clinics, Iowa City, has advocated prehospital and first-aid use of ordinary plastic wrap or cling film on burn wounds for almost two decades with very positive results, Edwin Clopton, a paramedic and ED technician, explained during a poster session at the annual meeting of the American Burn Association.

“Virtually every ambulance in Iowa has a roll of plastic wrap in the back,” Mr. Clopton said in an interview. “We just wanted to get the word out about the success we've had using plastic wrap for burn wounds,” he said.

Dr. G. Patrick Kealey, newly appointed ABA president and director of emergency general surgery at the University of Iowa Hospital and Clinics, said in an interview that plastic wrap reduces pain, wound contamination, and fluid losses. Furthermore, it’s inexpensive, widely available, nontoxic, and transparent, which allows for wound monitoring without dressing removal.

“I can’t recall a single incident of its causing trouble for the patients,” Dr. Kealey said. “We started using it as an answer to the problem of how to create a field dressing that met those criteria. I suppose that the use of plastic wrap has spread from here out to the rest of our referral base.”

Although protocols vary between different localities, plastic wrap is typically used for partial- and full-thickness thermal burns, but not superficial or chemical burns. It is applied in a single layer directly to the wound surface without ointment or dressing under the plastic and then secured loosely with roller gauze, as needed.

Because plastic wrap is extruded at temperatures in excess of 150° C, it is sterile as manufactured and handled in such a way that there is minimal opportunity for contamination before it is unrolled for use, said Mr. Clopton of the emergency care unit at Mercy Hospital, Iowa City. However, it’s best to unwind and discard the outermost layer of plastic from the roll to expose a clean surface.

Addendum No. 1

for

DNA 1240H-2, Part 2

HANDBOOK OF UNDERWATER NUCLEAR EXPLOSIONS

21 January 1974

M. J. Dudash
DASIAC
General Electric Company–TEMPO
816 State Street
Santa Barbara, CA 93102

19 August 1973 CHAPTER 18

18.7 THERMAL AND NUCLEAR RADIATION EFFECTS ON SURFACE SHIP PERSONNEL

18.7.1 Casualty and Risk Criteria

Table 18-2

CDC NUCLEAR AND THERMAL RADIATION CRITERIA

New Thermal Radiation Criteria

Risk Criteria for Burns Under Summer Uniforms to Warned, Exposed Personnel

	% Incidence	Mechanism	10KT cal/cm^2	100KT cal/cm^2	1000KT cal/cm^2
Negligible	2.5	1° burn	3.1	4.2	5.8
Moderate	5	1° burn	3.7	5.0	6.8
Emergency	5	2° burn	6.3	8.8	12

	Casualties due to 2nd Degree Burns			
Time to Ineffectiveness	% Incidence	10KT cal/cm^2	100KT cal/cm^2	1000KT cal/cm^2
24. hr	50	38	53	73

Personnel Risk and Casualty Criteria for Nuclear Weapons Effects
ACN 4260, U. S. Army Combat Developments Command Institute of Nuclear Studies, August 1971

EFFECTS OF SPECTRAL DISTRIBUTION OF RADIANT ENERGY ON CUTANEOUS BURN PRODUCTION IN MAN AND THE RAT

Research and Development Technical Report USNRDL-TR-46
NM 006-015

25 April 1955

by

E.L. Alpen
C.P. Butler
S.B. Martin
A.K. Davis

U.S. NAVAL RADIOLOGICAL DEFENSE LABORATORY
San Francisco 24, California

For human skin the reflectivities and critical energies for production of a standard burn are the following:

filter "A", $\lambda_{max} = 0.42\mu$, $r = 24.4 \pm 3.5$ per cent, $Q = 3.20 \pm 0.37$ cal/cm^2;

filter "B", $\lambda_{max} = 0.55\mu$, $r = 40.9 \pm 3.8$ per cent, $Q = 3.25 \pm 0.28$ cal/cm^2;

filter "C", $\lambda_{max} = 0.65\mu$, $r = 56.9 \pm 2.5$ per cent, $Q = 9.9 \pm 2.1$ cal/cm^2;

filter "D", $\lambda_{max} = 0.85\mu$, $r = 53.4 \pm 2.2$ per cent, $Q = 14.0 \pm 1.1$ cal/cm^2;

filter "F", $\lambda_{max} = 1.7\mu$, $r = 17 \pm 0.60$ per cent, $Q = 2.50$ cal/cm^2 (approx.).

The ranges shown are standard deviations.

The significance of the optical properties of skin has been discussed and the property of the high transmission of skin in the region 0.7 to 1.0 has been presented.

SUMMARY

The Problem

How does the critical energy for the production of standard burns in both rats and humans vary with the wavelength of radiant energy?

Findings

The critical radiant energy, corrected for spectral reflectance, required for production of standard burns in both rat and human skin varies as much as 4-fold depending on the wavelength.

EXPERIENCE OF GERMAN AND JAPANESE AIR RAIDS

Source: AD0642790, p. 8. Basic data:
Dirkwood DC-WP-1040-1, AD-827 029/0

City	Lives Lost	Percent of Population	Buildings Destroyed	Area Burned, sq mi
Tokyo	84,000	1.2	300,000	15.8 (total loss)
Hamburg	42,000	2.4	300,000	4.5 (total loss)
				12 (heavy damage)
Kassel	8,700	3.8	33,000	2.9 (total loss)
Darmstadt	8,100	7.4	22,000	1.5
Hiroshima	70,000*	28.0	68,000	4.4 (firestorm area)
Nagasaki	40,000*	17.0	21,000	0.049 (fire only)
				0.864 (fire and blast)

*Guest Korean workers, POWs, and military personnel excluded.

THE UNITED STATES

STRATEGIC BOMBING SURVEY

THE EFFECTS OF THE ATOMIC BOMB ON HIROSHIMA, JAPAN

Volume I

Physical Damage Division

May 1947

G. CAUSE AND EXTENT OF FIRE

1. Conditions Prior to Attack

The city of Hiroshima was an excellent target for the atomic bomb from a fire standpoint: There had been no rain for three weeks; the city was highly combustible, consisting principally of Japanese domestic-type structures; it was constructed over flat terrain; and 13 square miles (including streets) of the 26.5-square-mile city was more than 5 percent built up (i. e., covered by plan areas of buildings). The remainder of the city comprised water areas, parks and areas built up below 5 percent. Sixty-eight percent of the 13-square-mile area was 27 to 42 percent built up and the 4-square-mile city center was particularly dense, 93.6 percent of it being 27 to 42 percent built up.

a. Evidence relative to ignition of combustible structures and materials by heat directly radiated by the atomic bomb and by other ignition sources developed the following: (1) The primary fire hazard was present in combustible materials and in fire-resistive buildings with unshielded wall openings; (2) six persons who had been in reinforced-concrete buildings within 3,200 feet of air zero stated that black cotton black-out curtains were ignited by radiant heat; (3) a few persons stated that thin rice paper, cedarbark roofs, thatched roofs, and tops of wooden poles were afire immediately after the explosion; (4) dark clothing was scorched, and, in some cases, reported to have burst into flame from flash heat; (5) but a large proportion of over 1,000 persons questioned was in agreement that a great majority of the original fires was started by debris falling on kitchen charcoal fires, by industrial process fires, or by electric short circuits.

b. Hundreds of fires were reported to have started in the center of the city within ten minutes after the explosion. Of the total number of buildings investigated 107 caught fire, and, in 69 instances, the probable cause of initial ignition of the buildings or their contents was established as follows: (1) 8 by direct radiated heat from the bomb (primary fire), (2) 8 by secondary sources and (3) 53 by fire spread from exposing buildings.

3. Conditions on Morning of Attack

a. The morning of 6 August 1945 was clear with a small amount of clouds at high altitude. Wind was from the south with a velocity of about 4½ miles per hour. Visibility was 10 to 15 miles.

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(1) Only a few persons remained in the air-raid shelters after the "all-clear" sounded.

THE UNITED STATES
STRATEGIC BOMBING SURVEY

THE EFFECTS OF THE ATOMIC BOMB ON HIROSHIMA, JAPAN

Volume II

Physical Damage Division

Dates of Survey:

14 October–26 November 1945

Date of Publication

May 1947

4. The city, consisting principally of Japanese domestic structures, was highly combustible and densely built up. Sixty-eight percent of the 13-square-mile city area was 27 to 42 percent built up and the 4-square-mile city center was particularly dense, 94 percent of it being 27 to 42 percent built up. All the large industrial plants were located on the south and southeast edges of the city.

8. Evidence relative to ignition of combustible structures and materials by directly radiated heat from the atomic bomb and other ignition sources was obtained by interrogation and visual inspection of the entire city. Six persons who had been in reinforced-concrete buildings within 3,200 feet of air zero stated that black cotton black-out curtains were ignited by flash heat. A few persons stated that thin rice paper, cedarbark roofs, thatched roofs, and tops of wooden poles were afire immediately after the explosion. Dark clothing was scorched and, in some cases, was reported to have burst into flame from flash heat. A large proportion of over 1,000 persons questioned was, however, in agreement that a great majority of the original fires were started by debris falling on kitchen charcoal fires. Other sources of secondary fire were industrial-process fires and electric short circuits.

9. There had been practically no rain in the city for about 3 weeks. The velocity of the wind on the morning of the atomic-bomb attack was not more than 5 miles per hour.

10. Hundreds of fires were reported to have started in the center of the city within 10 minutes after the explosion.

4

PHOTO 36 IX. Shows partly burned coat of boy who was in open near City Hall (Building 28) 3,800 feet from AZ.

(8) Scores of persons throughout all sections of the city were questioned concerning the ignition of clothing by the flash from the bomb. Replies were consistent that white silk seldom was affected, although black, and some other colored silk, charred and disintegrated. Numerous instances were reported in which designs in black or other dark colors on a white silk kimono were charred so that they fell out, but the white part was not affected. These statements were confirmed by United States medical officers who had been able to examine a number of kimonos available in a hospital. Ten school boys were located during the study who had been in school yards about 6,200 feet east and 7,000 feet west, respectively, from AZ. These boys had flash burns on the portions of their faces which had been directly exposed to rays of the bomb. The boys' stories were consistent to the effect that their clothing, apparently of cotton materials, "smoked," but did not burst into flame. Photo 36 shows a boy's coat that started to smolder from heat rays at 3,800 feet from AZ.

(3300 from GZ)

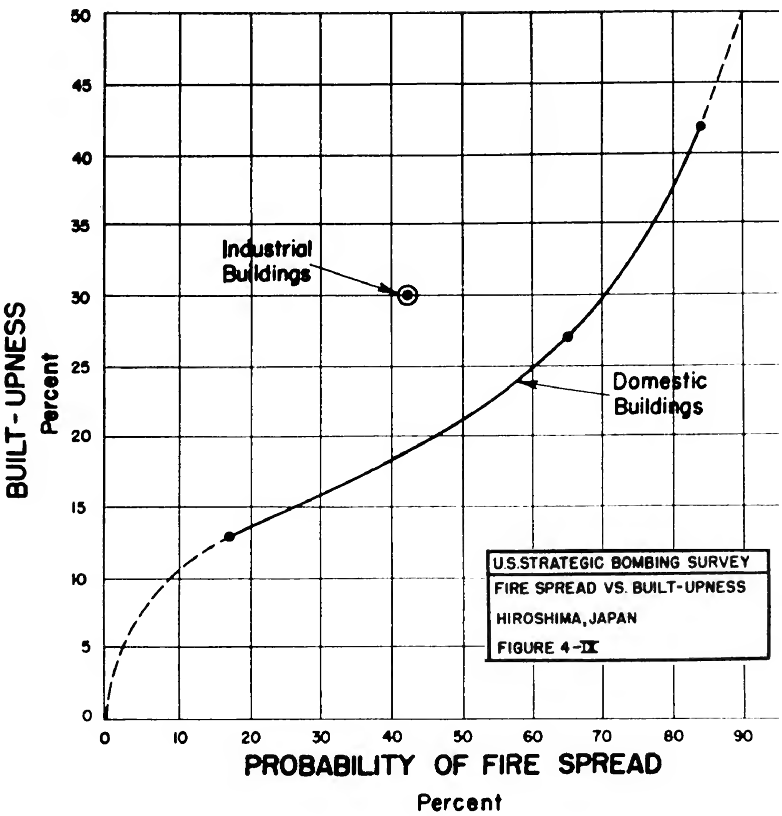
24

D. THE CONFLAGRATION

1. Start of Fire

b. Direct Ignition by the Atomic Bomb. (1) Six persons were found who had been in reinforced-concrete buildings within 3,200 feet of AZ at the time of the explosion and who stated that black cotton black-out curtains were blazing a few seconds later. In two cases it was stated that thin rice paper on desks close to open windows facing AZ also burst into flame immediately, although heavier paper did not ignite. No incidents were recounted to the effect that furniture or similar objects within buildings were ignited directly by radiated heat from the bomb.

21



(4) It was reported that a cotton black-out curtain at an unprotected window in the east stair tower of Building 85 (3,800 feet from AZ) smoked and was scorched by radiated heat from the bomb but it did not burst into flames.

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(5) A man who was in the third story of building 26 (3,000 feet from AZ) stated that radiated heat from the bomb ignited cotton black-out curtains at unprotected windows in the west wall and thin rice paper on desks.

47

(10) Fire fighting with water buckets was reported inside only four buildings (24, 33, 59, and 122) and probably prevented extensive fire damage in them. In Building 24, fire was started in contents of a room at the southwest corner of the second story by sparks from trees on the south side about 1½ hours after the attack. Men inside the building extinguished the fire and probably prevented further damage in the first and second stories (Photo 85). A little later, contents in the third story were ignited by sparks from the outside and were totally damaged. This fire was beyond control before it was discovered, but did not spread downward through open stairs. At Building 33, sparks from the west exposure, which burned in early evening, set fire to black-out curtains in the west wall and to waste paper in the fourth story of the northwest section of the building. Twenty persons were on guard in the building awaiting such an occurrence and the fires were quickly extinguished while in the incipient stage. At Building 59 sparks from the south exposure ignited a few pieces of furniture in the first and third stories and black-out curtains in the first story about 2 hours after the attack. These fires were extinguished by men inside and negligible damage resulted. A few window frames in the east and west walls and 2 or 3 desks in the first story of Building 122 were ignited by radiated heat and sparks from the west and northeast exposures. These fires were extinguished quickly and damage was negligible.

58

A. SUMMARY

4. The mean areas of effectiveness (MAE) of the atomic bomb for structural damage about ground zero (GZ) and the radii of the MAE's for the several classes of buildings present were computed to be as follows:

	MAE's in square miles	Radii of MAE's in feet
Multistory, earthquake-resistant	0.03	500
Multistory, steel- and reinforced-concrete frame (including both earthquake- and non-earthquake-resistant construction)	.05	700
1-story, light, steel-frame	3.4	5,500
Multistory, load-bearing, brick-wall	3.6	5,700
1-story, load-bearing, brick-wall	6.0	7,300
Wood-frame industrial-commercial (dimension-timber construction)	8.5	8,700
Wood-frame domestic buildings (wood-pole construction)	9.5	9,200
Residential construction	6.0	7,300

96

U. S. STRATEGIC BOMBING SURVEY

PHYSICAL DAMAGE DIVISION

Field Team No. 1, Hiroshima, Japan

BUILDING ANALYSIS

SHEET No. 1

Building No.: 24. Coordinates: 5H. Distance from (GZ): 1,300, (AZ): 2,400.
NAME: Bank of Japan, Hiroshima branch.
CONSTRUCTION AND DESIGN
Type: Reinforced-concrete frame (steel core).
Number of Stories: 3 and basement. JTG class: E1.
Roof: Reinforced-concrete beam and slab.
Partitions: Reinforced concrete and wood lath.
Walls: Reinforced concrete (12-inch) and stone (6-inch).
Floors: Reinforced concrete.
Framing: Reinforced concrete.
Window and door frames: Metal (exterior) wood (interior). Ceilings: Plaster on concrete.
Condition, workmanship, and materials: Excellent.
Compare with usual United States buildings: Much stronger—steel core construction.
OCCUPANCY: Bank.
CONTENTS: Bank and office equipment furnishings.
DAMAGE to building: Only minor damage—top story burned out, partitions, sash, trim blown out in two lower stories.
Cause: Fire.
To Contents: Destroyed in third story—moderate debris and blast damage in first and second stories, none in basement.
Cause: Fire and debris (about equally).
TOTAL FLOOR AREA (square feet): 32,800. Structural damage: —. Superficial damage:
FRACTION OF DAMAGE: Building structural: —. Superficial: —. Contents: 30 percent.
REMARKS: Glass removed from skylight (20 by 20 feet) and light steel-frame structure and roof covered with 12 to 18 inches of sand and cinders.

NOTE.—Building damage based on total floor area. Contents damage is fraction of contents seriously damaged.

SHEET No. 2

(Fire Supplement to Sheet No. 1)

Building No.: 24. Fire classification: R.
WALL OPENINGS: Shutters: Steel rollers.
Shut: Part.
Effect of blast: Blown in.

FLOOR OPENINGS:

	Enclosed	Fire doors	Automatic	Effect of blast
Stairs:	Part	Steel rollers	No	None—doors open.
Elevators:	Yes	Metal and W. G.	No	Bent.

EXPOSURE:

Location	Distance	Firebreak Clearance	Fire Class	Burned	Remarks
N	25'	No	C	Yes	14-foot concrete wall between.
E	25'	No	R	Yes	Building 25 (14-foot wall between).
S	—	No	—	—	No exposure.
W	125'	Yes	C	Yes	

PROBABLE CAUSE OF FIRE: Fire spread from exposures.
VERTICAL FIRE SPREAD: No.
EXTENT OF FIRE: Total floor area: 32,800 square feet. Floor area burned: 5,200 square feet; 16 percent (after blast damage).

REMARKS: Fire only in room at southwest corner of second story and in entire third story. No fire in building right after bomb, but afire at 1000 hours. Fire in room in second story extinguished with water buckets.

U. S. STRATEGIC BOMBING SURVEY

PHYSICAL DAMAGE DIVISION

Field Team No. 1, Hiroshima, Japan

BUILDING ANALYSIS

Sheet No. 1

Building No.: 59. Coordinates: 5I. Distance from (GZ): 4,100, (AZ): 4,500.

NAME: Geibi Bank Co., Hiroshima Branch (in use at time of bomb as the Higashi Police Station).

CONSTRUCTION AND DESIGN

Type: Reinforced-concrete frame.

Number of stories: See sketch. JTG class: E1.

Roof: Reinforced-concrete beam and slab.

Partitions: 7-inch reinforced concrete.

Walls: 8-inch reinforced concrete monolithic—medium window.

Floors: Reinforced-concrete beam and slab—parquet and tile.

Framing: Reinforced-concrete beam and slab.

Window and door frames: Steel. Ceilings: Sheet metal on wood framing.

Condition, workmanship and materials: Good.

Compare with usual United States buildings: Appreciably stronger than United States design.

OCCUPANCY: Police station (office).

CONTENTS: Office equipment.

DAMAGE to building: Minor damage only—sash blown out and hung ceilings partially stripped.

Cause: Blast.

To contents: Slight damage to contents from blast and debris.

Cause: Blast.

TOTAL FLOOR AREA (square feet): 16,200. Structural damage: —. Superficial damage:

FRACTION OF DAMAGE: Building. Structural: Superficial: Contents: 10 percent.

REMARKS:

Note.—Building damage based on total floor area. Contents damage is fraction of contents seriously damaged.

Sheet No. 2

(Fire Supplement to Sheet No. 1)

Building No.: 59. Fire classification: R.

WALL OPENINGS: Shutters: Steel rollers in east wall and third story of south and west walls (wired glass in all windows).

Effect of blast: Blown in at west wall, bent at south wall.

FLOOR OPENINGS:

	Enclosed	Fire doors	Automatic	Effect of blast
Stairs:	Yes	Metal	No	Bent slightly.
Elevators:				

EXPOSURE:

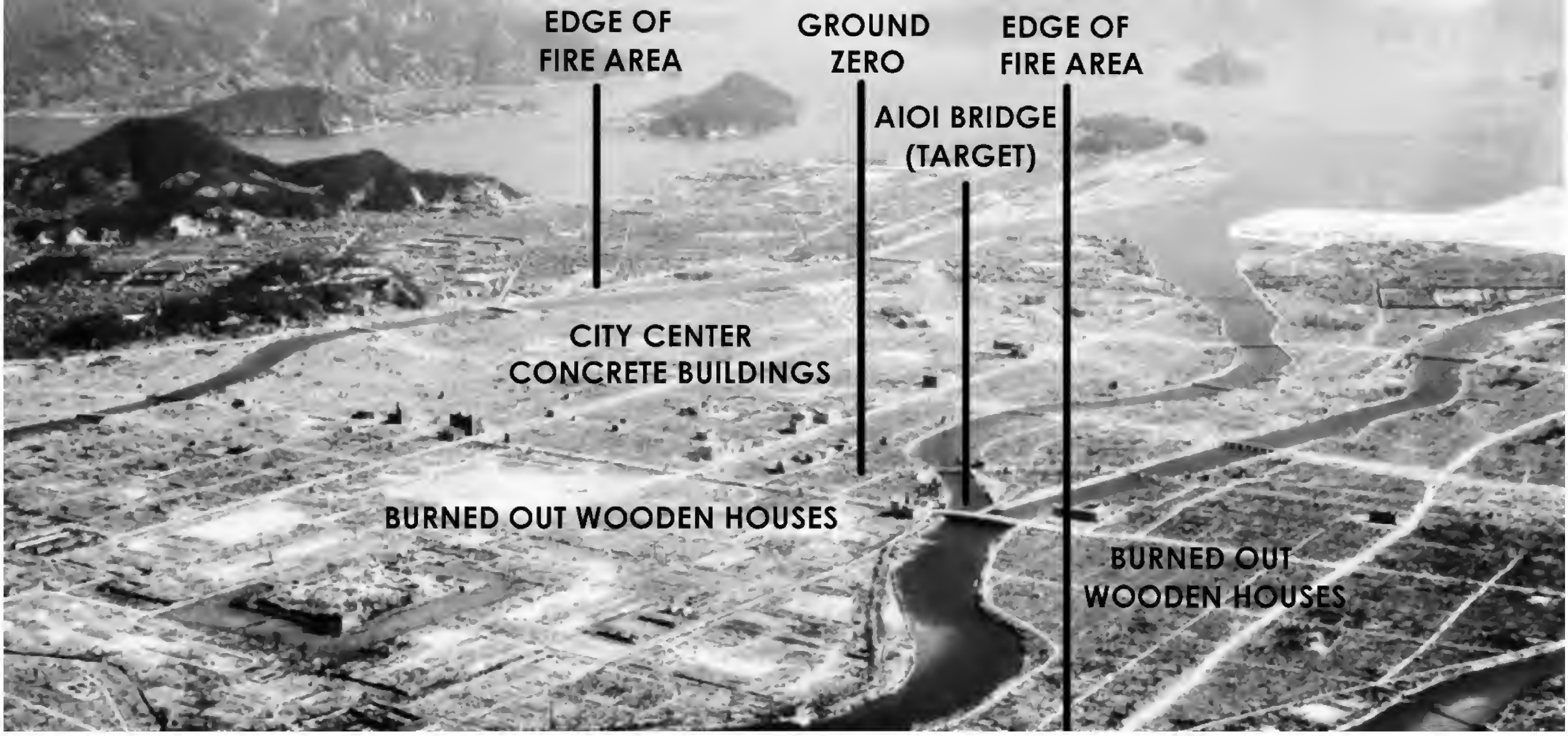
Location	Distance	Firebreak Clearance	Fire Class	Burned	Remarks
N	150′	Yes	C	Yes	
E	60′	Yes	C	Yes	
S	30′	Partial 100′	C	Yes	All exposures burned.
W	60′	Yes	C	Yes	

PROBABLE CAUSE OF FIRE: Fire spread from exposures.

VERTICAL FIRE SPREAD: No.

EXTENT OF FIRE: Total floor area: 16,200 square feet. Floor area burned: 0 square feet; 0 percent (after blast damage).

REMARKS: Sparks from south exposure ignited few pieces of furniture in first and third stories and cotton blackout curtains in first story about 1030 hours. Fires were extinguished with water buckets by people inside. Negligible fire damage resulted. Some of exposing buildings had just been removed prior to the bomb.


EDGE OF FIRE AREA
GROUND ZERO
EDGE OF FIRE AREA
AIOI BRIDGE (TARGET)
CITY CENTER CONCRETE BUILDINGS
BURNED OUT WOODEN HOUSES
BURNED OUT WOODEN HOUSES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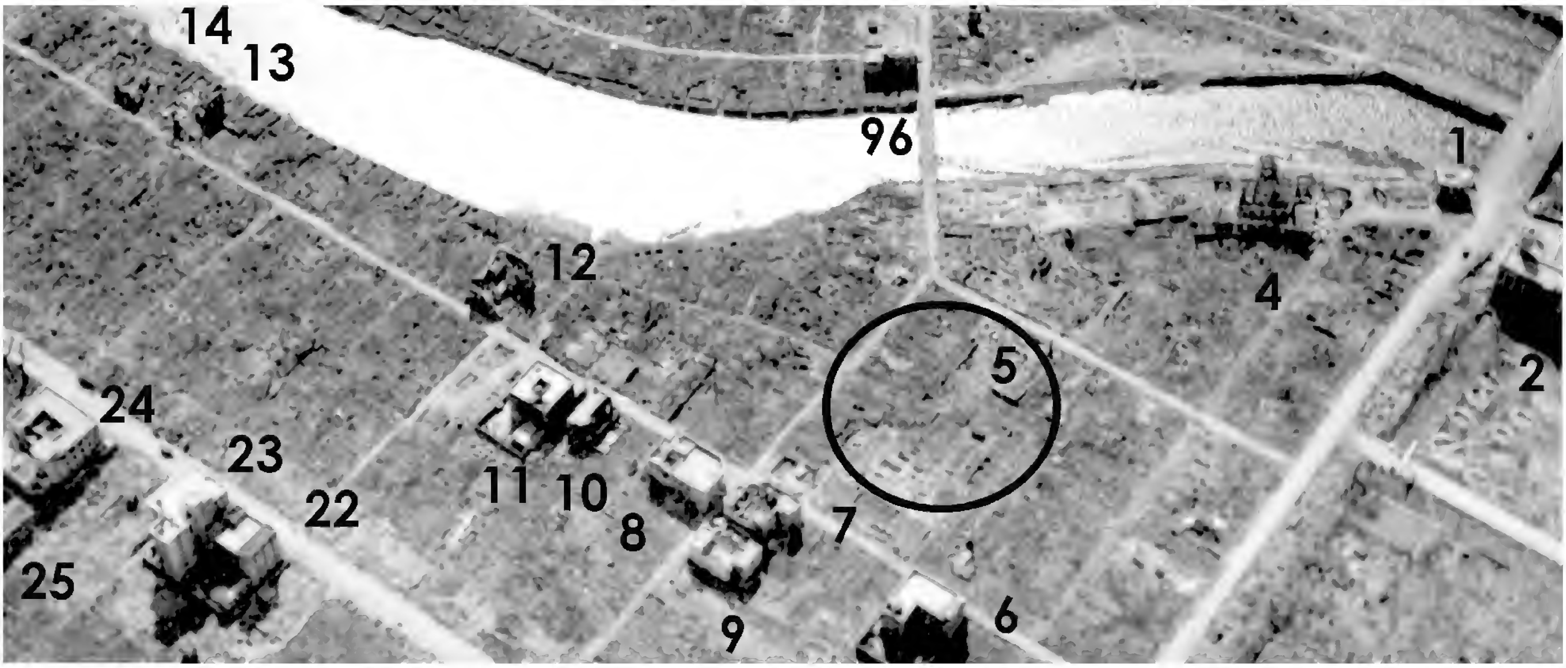
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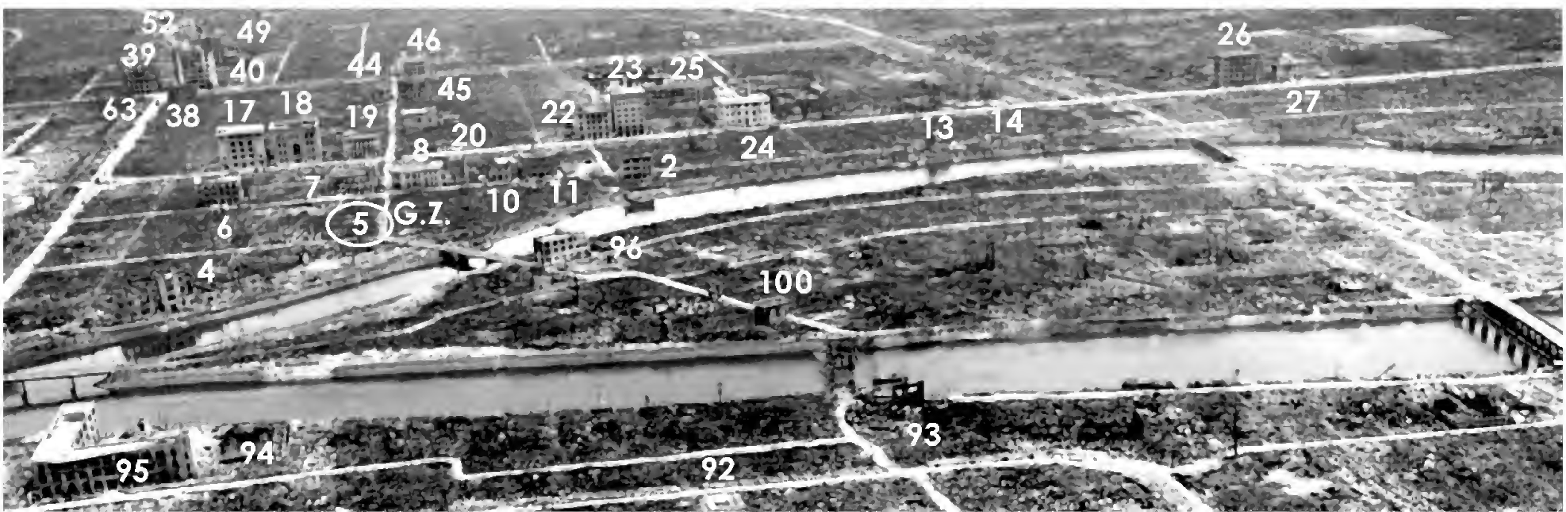
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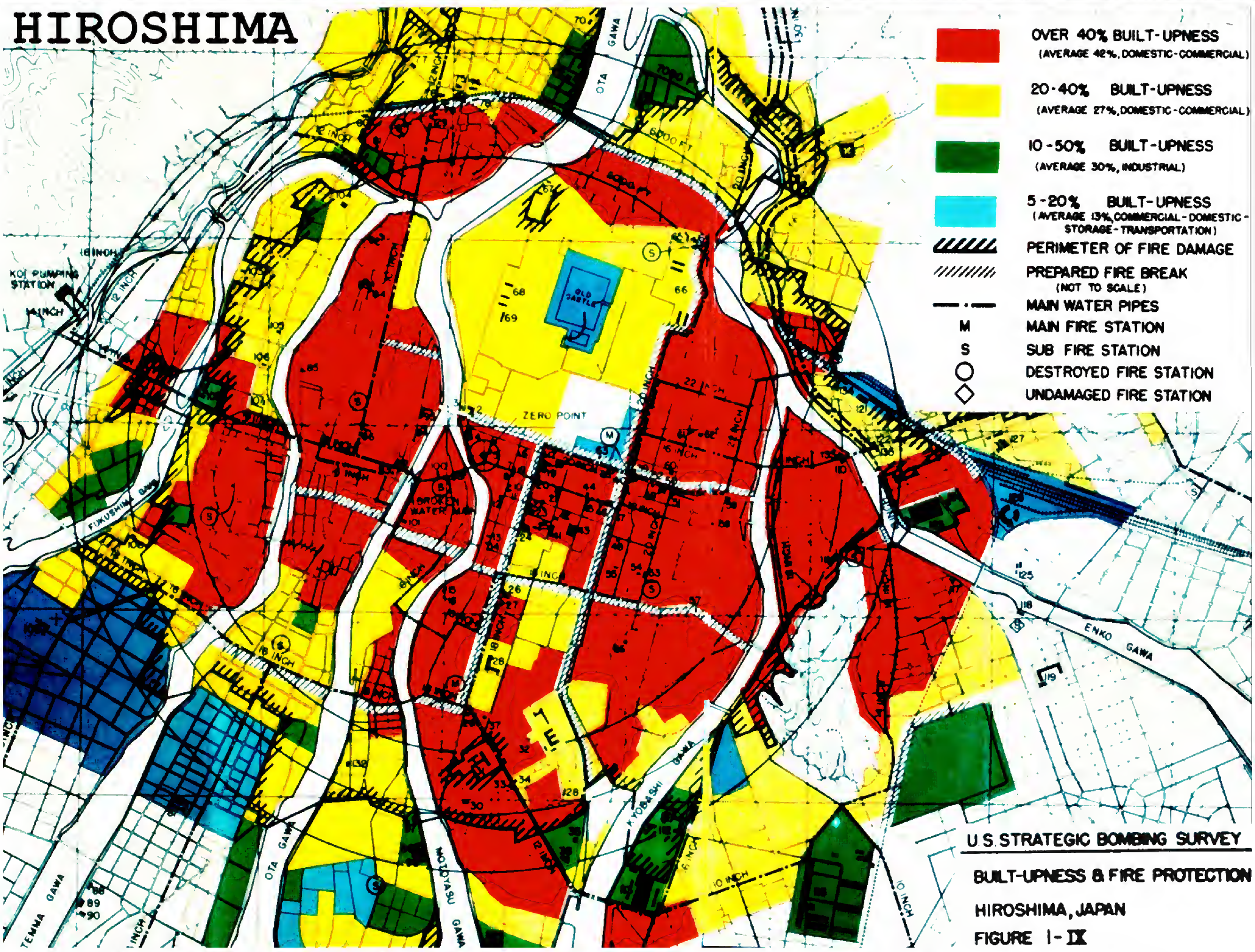


SOURCE: USSBS's report, "The Effects of the Atomic Bomb on Hiroshima, Japan," vol. 2
Only 8 of 64 non-wood buildings had thermal flash ignition evidence, 3 had blast damage induced fire, and 28 were ignited by firespread from wood homes.

15 min. (Enola Gay)
Hiroshima fires merging

HIROSHIMA
500 m
Hirose Grade School
HIROSE KITAMACHI
DOBASHI
5th Transport Battalion
5th Field Artillery Regiment
Hiroshima Castle
Imperial Hq
5th Division Hq
Clothing Warehouse
11th Infantry Regiment
Revenue Office
Military Academy
6.3
NISHI-KUKENCHO
NISHI-HIKIMI-DOCHO
SOBOZAYACHO
TAKAJO-MACHI
Honkawa Grade School
Regimental Headquarters
NISHI DRILL FIELD
SHIN-AIOI BASHI
Steel
Electric Transformer Station
AIOI BASHI
Division Commanders' Quarters
2.64
Saibi Grade School
HATCHOBORI
Military Police
Officers' Club
KAJIYA-CHO
Commercial Display Hall
SARUGAKUCHO
SAIKU MACHI
ABURAYACHO
Canning Factory
NAKAJIMA-HOMMACHI
TOGIYACHO
Dept. Store
HONKAWA -BASHI
Stone
MOTOYASU -BASHI
Nishio Mat Factory
TATEMACHI
Fish Market
EBISUCHO
Telephone Office
NISHI JIKATA-MACHI
TSUKAMOTOCHO
NAKAJIMA-HOMMACHI
FIRE LANE
Steel
ZAI-MOKU-CHO
TENJIM-MACHI
ONOMICHICHO
FUKURO-MACHI
SHIN Ō-HASHI
NAKAJIMA SHIMMACHI
KOBIKICHO
Steel
Kokutai-ji
Hotel
Court of Appeals
KO-MACHI
Girls High School
SHIMONAKACHO
HORIKAWA CHO
MIKAWACHO
SHIMO NAGAREKAWACHO
Court
Prefectural Hospital
Electric Substation
Elec Co
School for Blind and Dumb
Bank of Japan
Prefectural Office
ŌTEMACHI
Asano Library
Commercial School
TANAKA-MACHI
FIRE LANE
Nakajima Grade School
BANTAI -BASHI
Public Hall
Daiichi Middle School
Sumori Plate Factory
ATHLETIC FIELD
Ote Grade School
TAKEYACHO
Sanyō Middle School
Hasegawa Knitting Mill
Girls' High School
ZAKOBACHO
TAKARAMACHI
Fish Market
Commercial School
Steel
Paper Mill
MEIJI -BASHI
City Hall
SUMIYOSHI -BASHI

Building No.: 5. Coordinates: 5H. Distance from (GZ): 100, (AZ): 2,000.
NAME: Shima Surgical Hospital.
CONSTRUCTION AND DESIGN
Type: Bearing wall.
Number of stories: 1. JTG class: A 2-3.
Roof: Tile over wood on wood truss.
Partitions: Plaster on wood lath and studs.
Walls: Brick-bearing, 18 inches.

Building No.: 6. Coordinates: 5H. Distance from (GZ): 600, (AZ): 2,100.
NAME: Chiyoda Life Insurance Co., Chugoku branch.
CONSTRUCTION AND DESIGN
Type: Reinforced-concrete frame.
Number of stories: Three and basement. JTG class: E1.
Roof: Reinforced-concrete beam and slab-tile covered.
Partitions: Reinforced-concrete, major—metal lath and plaster, minor.
Walls: Reinforced-concrete panels, 10 inches. Reinforced-concrete granite facing.

Building No.: 10 Coordinates: 5H. Distance from (GZ): 600, (AZ): 2,100.

NAME: Nippon Life Insurance Co., Hiroshima branch.

CONSTRUCTION AND DESIGN

Type: Load-bearing brick wall.

Number of stories: See drawing. JTG class: F2.

Roof: Reinforced-concrete slab 6 inch (¾-inch bars 6-inch oc by 12 inch oc).

Building No.: 18. Coordinates: 5H. Distance from (GZ): 1,000, (AZ): 2,200.

NAME: Geibi Bank Co., Hiroshima Branch.

CONSTRUCTION AND DESIGN

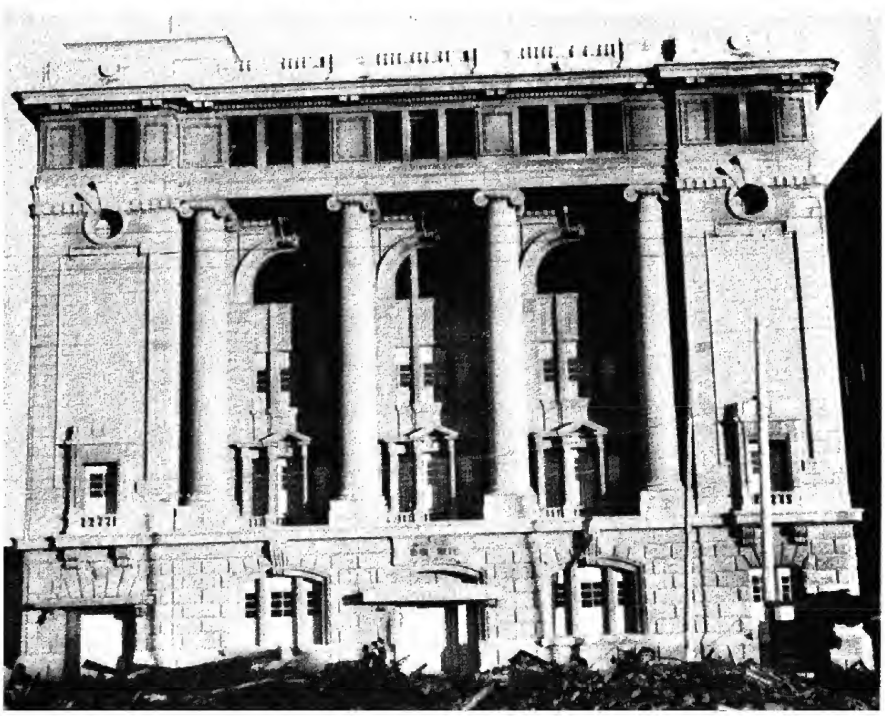
Type: Reinforced-concrete frame.

Number of stories: 5 and ½ basement. JTG class: E1.

Roof: Reinforced-concrete slab (metal pan).

Partitions: Reinforced-concrete (5-inch). Wood lath and plaster in rear addition.

Walls: Reinforced concrete (10-inch).



Building No.: 23. Coordinates: 5H. Distance from (GZ): 1,200; (AZ); 2,300.

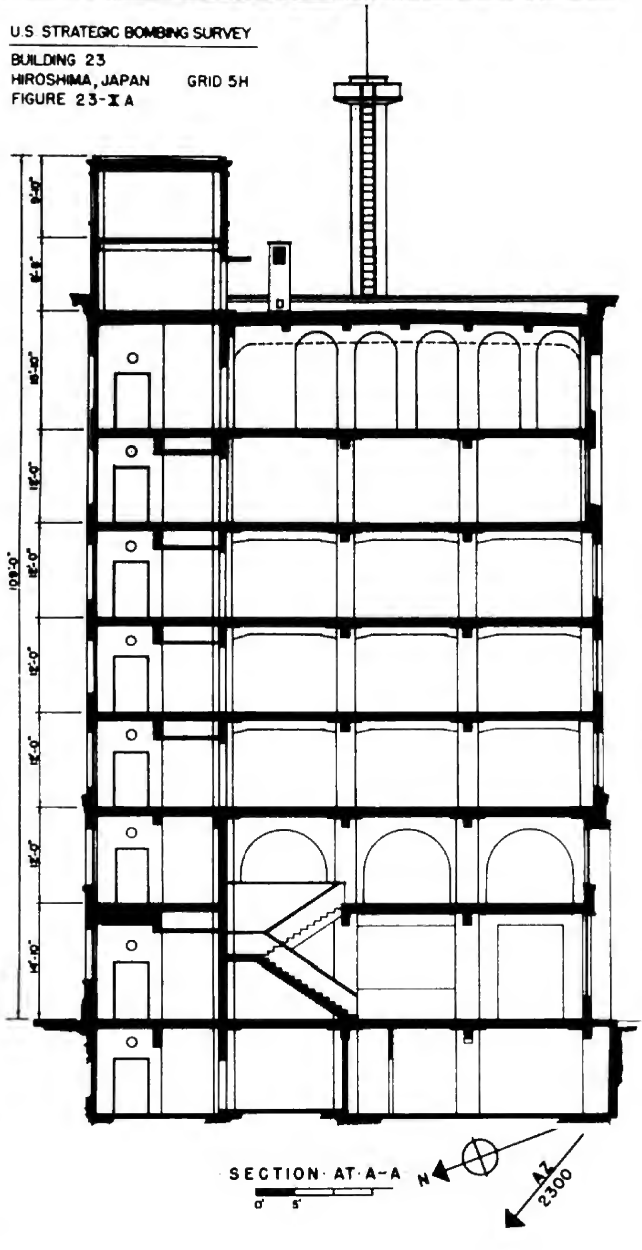
NAME: Fukoku Building.

CONSTRUCTION AND DESIGN

Type: Steel core reinforced-concrete frame.

Number of stories: 7 and basement. JTG class: E1.

Roof: Reinforced-concrete beam and slab (steel core).



Building No.: 26. Coordinates: 5H. Distance from (GZ): 2,300, (AZ): 3,000.

NAME: Chugoku Electric Co.

CONSTRUCTION AND DESIGN

Type: Reinforced-concrete frame.

Number of stories: 5 and basement and penthouse JTG class: E1.

Walls: Reinforced concrete (12-inch).

REMARKS: Fire throughout building except in 60 percent of basement (no fire in basement of west section and about 25 percent of east section). Man who was in third story stated that he saw cotton blackout curtains in west wall and thin paper on desks catch fire from flash of bomb. Fire was reported to have been in all stories 5 minutes after bomb.

Building No.: 40. Coordinates: 5H. Distance from (GZ): 2,500, (AZ): 3,200.

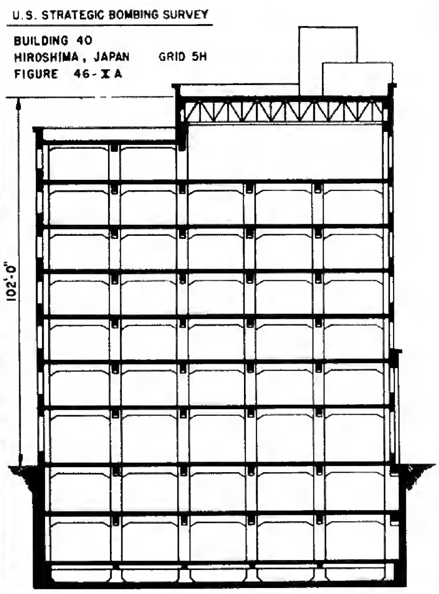
NAME: Fukuya Department Store.

CONSTRUCTION AND DESIGN:

Type: Reinforced-concrete frame.

Walls: 8-inch reinforced concrete—large windows.

REMARKS: Three persons who were questioned individually stated that this building was afire immediately or within 20 minutes after the bomb. One man who was in the building at the time stated that cotton blackout curtains in the west wall were smouldering immediately after the bomb. The entire building was afire at 1000 hours.



Building No.: 24. Coordinates: 5H. Distance from (GZ): 1,300, (AZ): 2,400.

NAME: Bank of Japan, Hiroshima branch.

CONSTRUCTION AND DESIGN

Type: Reinforced-concrete frame (steel core).

Walls: Reinforced concrete (12-inch) and stone (6-inch).

Floors: Reinforced concrete.

Framing: Reinforced concrete.

REMARKS: Fire only in room at southwest corner of second story and in entire third story. No fire in building right after bomb, but afire at 1000 hours. Fire in room in second story extinguished with water buckets.

Building No.: 33. Coordinates: 6H. Distance from (GZ): 5,300, (AZ): 5,600.

NAME: Hiroshima Postal Savings Bureau.

CONSTRUCTION AND DESIGN

Type: Reinforced-concrete frame.

Number of stories: 4 and basement. JTG class: E1.

Roof: Reinforced concrete, tile finish.

Partitions: Reinforced concrete.

Walls: Reinforced concrete, tile finish.

REMARKS: Sparks from west exposure ignited cotton black-out curtains in west wall at 2000 hours and waste paper in fourth story of northwest section at 2100 hours. Fires were extinguished with water buckets by 20 fire guards who were stationed inside. Fire damage to contents was negligible. Paper records stored in wood and steel racks in northeast section of building were exposed to direct radiated heat from bomb but did not catch fire.

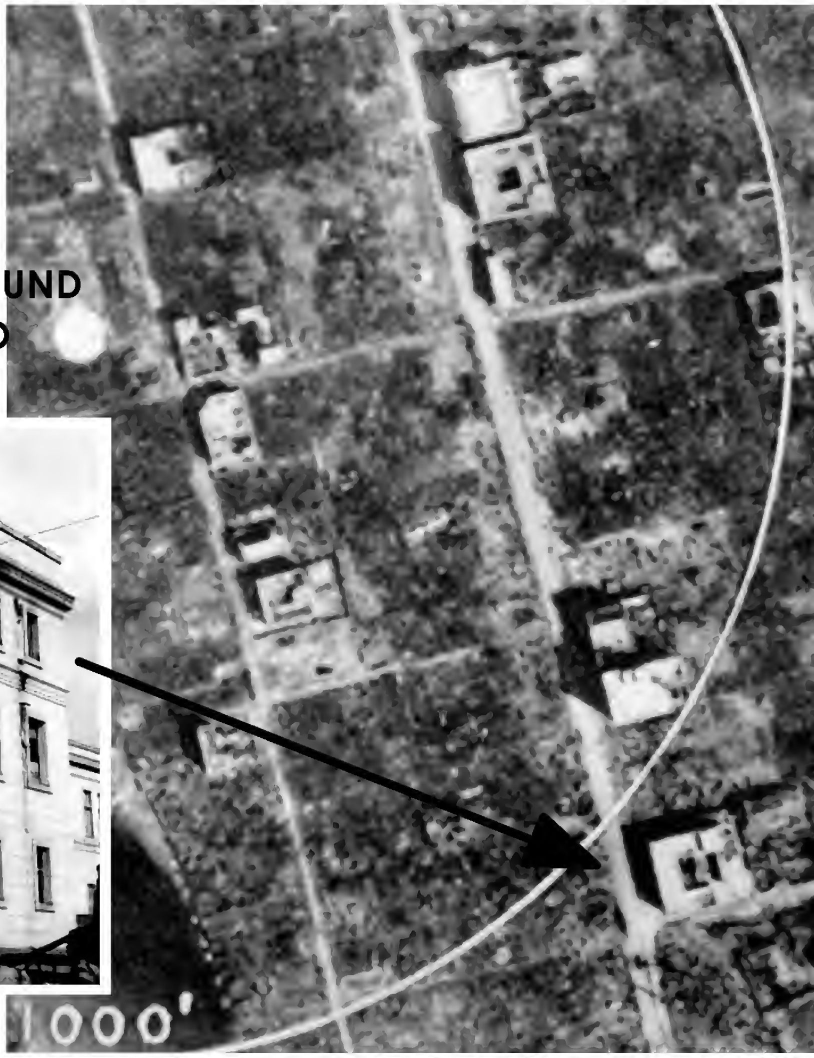
Building No.: 86. Coordinates: 5G. Distance from (GZ): 2,000, (AZ): 2,800.
NAME: Kōkō Private Grammar School.
CONSTRUCTION AND DESIGN
Type: Reinforced concrete.
Number of stories: Three. JTG class: E1.
Roof: Reinforced-concrete slab.
Partitions: 9-inch brick and 6-inch reinforced concrete.
Walls: Reinforced concrete (8–10 inches).

Building No.: 59. Coordinates: 5I. Distance from (GZ): 4,100, (AZ): 4,500.
NAME: Geibi Bank Co., Hiroshima Branch (in use at time of bomb as the Higashi Police Station).
CONSTRUCTION AND DESIGN
Type: Reinforced-concrete frame.
Walls: 8-inch reinforced concrete monolithic—medium window.
EXTENT OF FIRE: Total floor area: 16,200 square feet. Floor area burned: 0 square feet; 0 percent (after blast damage).
REMARKS: Sparks from south exposure ignited few pieces of furniture in first and third stories and cotton blackout curtains in first story about 1030 hours. Fires were extinguished with water buckets by people inside. Negligible fire damage resulted. Some of exposing buildings had just been removed prior to the bomb.

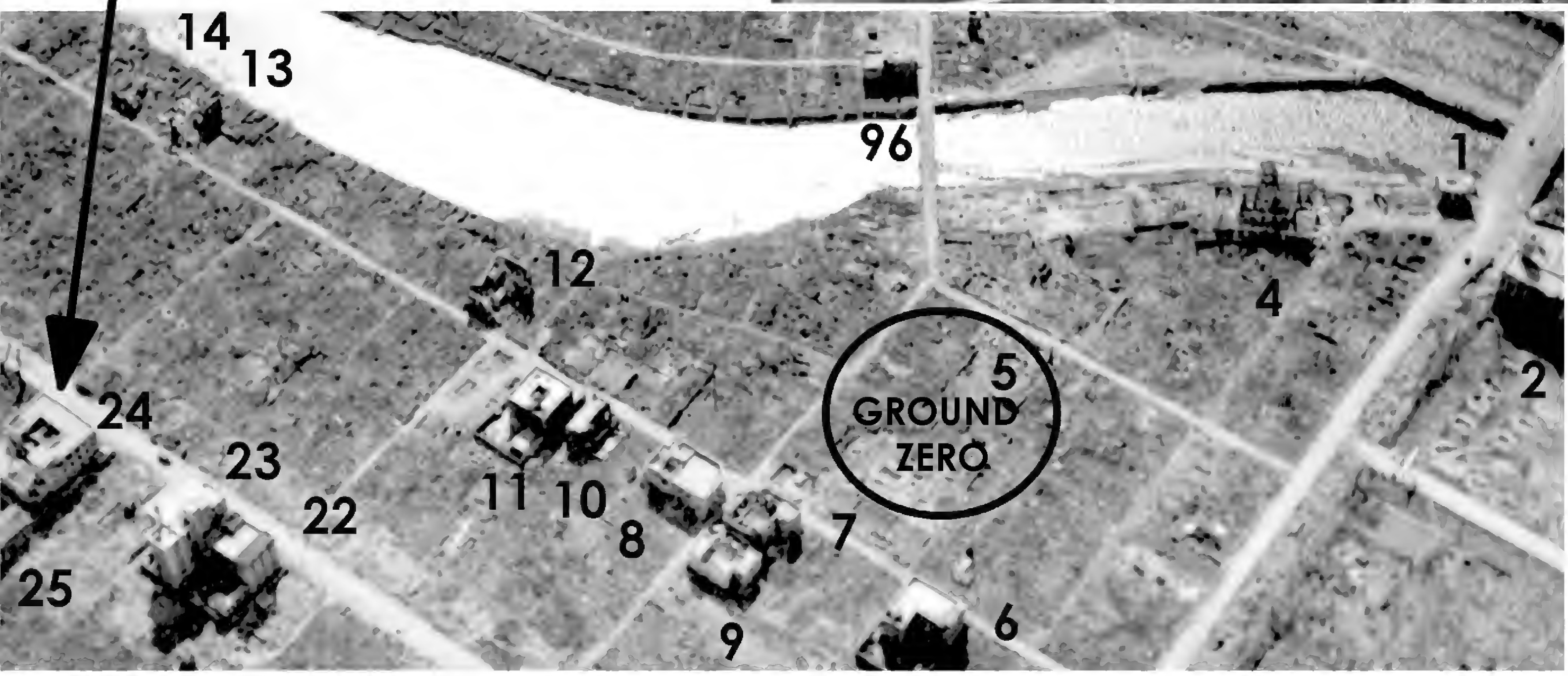
Building No.: 49. Coordinates: 5I. Distance from (GZ): 3,000, (AZ): 3,600.
Name: Chūgoku Newspaper.
CONSTRUCTION AND DESIGN
Type; Reinforced-concrete frame.
Number of Stories: 7 and penthouse. JTG class: E1.
Roof: Reinforced-concrete beam and slab.
Partitions: Reinforced concrete—lath and plaster.
Walls: 7-inch reinforced concrete—large windows.
REMARKS: Man who was in building at time of bomb stated fire broke out in third and fourth stories immediately after bomb flash. Head bookkeeper in bank in Building 51 stated that there was fire in third story of Building 49, 10 minutes after bomb flash.

Building No.: 96. Coordinates: G5. Distance from (GZ): 400 (AZ): 2,000.
NAME: Taisho Clothing Store.
Walls: Reinforced concrete (10-inch)

Building No.: 24. Coordinates: 5H. Distance from (GZ): 1,300, (AZ): 2,400.
NAME: Bank of Japan, Hiroshima branch.
CONSTRUCTION AND DESIGN
Type: Reinforced-concrete frame (steel core).
Walls: Reinforced concrete (12-inch) and stone (6-inch).
Floors: Reinforced concrete.
Framing: Reinforced concrete.
REMARKS: Fire only in room at southwest corner of second story and in entire third story. No fire in building right after bomb, but afire at 1000 hours. Fire in room in second story extinguished with water buckets.



U.S. Strategic Bombing Survey report 92



DISASTER AND RECOVERY: A HISTORICAL SURVEY

Jack Hirshleifer

MEMORANDUM
RM-3079-PR
1963

AD 403337

The RAND Corporation
SANTA MONICA • CALIFORNIA

As at Hamburg, people proved tougher than structures. Almost 70 per cent of the buildings in Hiroshima were destroyed, compared with around 30 per cent of population.[1]

The Research Department of the Hiroshima Municipal Office is reported to have estimated the population in the city as 407,000, in _Hiroshima_ (Hiroshima Publishing Company, 1949).

[1]These proportions are the estimates used by the U.S. Strategic Bombing Survey report. The Hiroshima Municipal Office calculations show an even greater disparity, reporting 22 per cent of population killed and missing but some 89 per cent of buildings as destroyed or needing reconstruction (_Hiroshima_).

On August 7 power was generally restored to surviving areas, and through railroad service commenced on August 8. Telephone service started on August 15. Hiroshima was also not a dead city. The U.S. Strategic Bombing Survey reported that plants responsible for three-fourths of the city's industrial production could have resumed normal operations within 30 days (the newer and larger plants in Hiroshima were on the outskirts of the city, and both physical premises and personnel generally survived).[1] By mid-1949 the population had grown to over 300,000 once more, and 70 per cent of the destroyed buildings had been reconstructed.[2]

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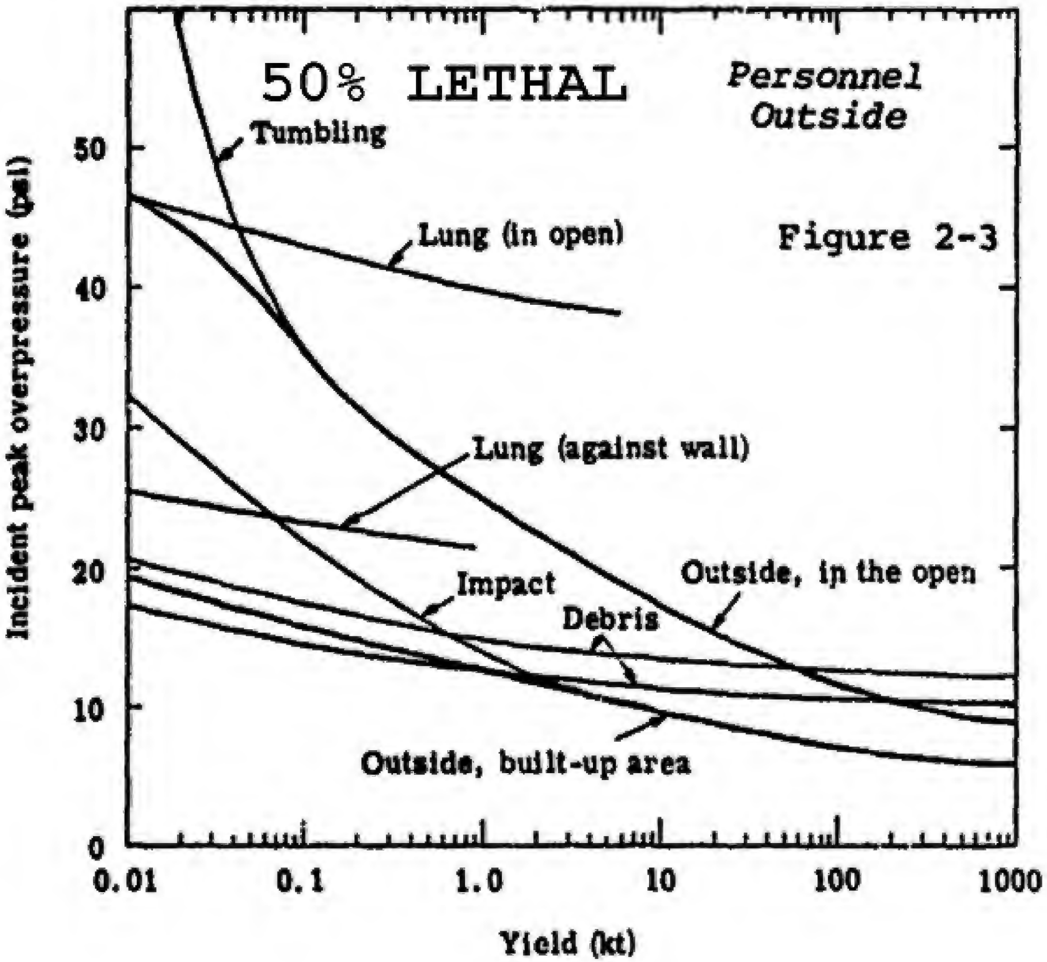
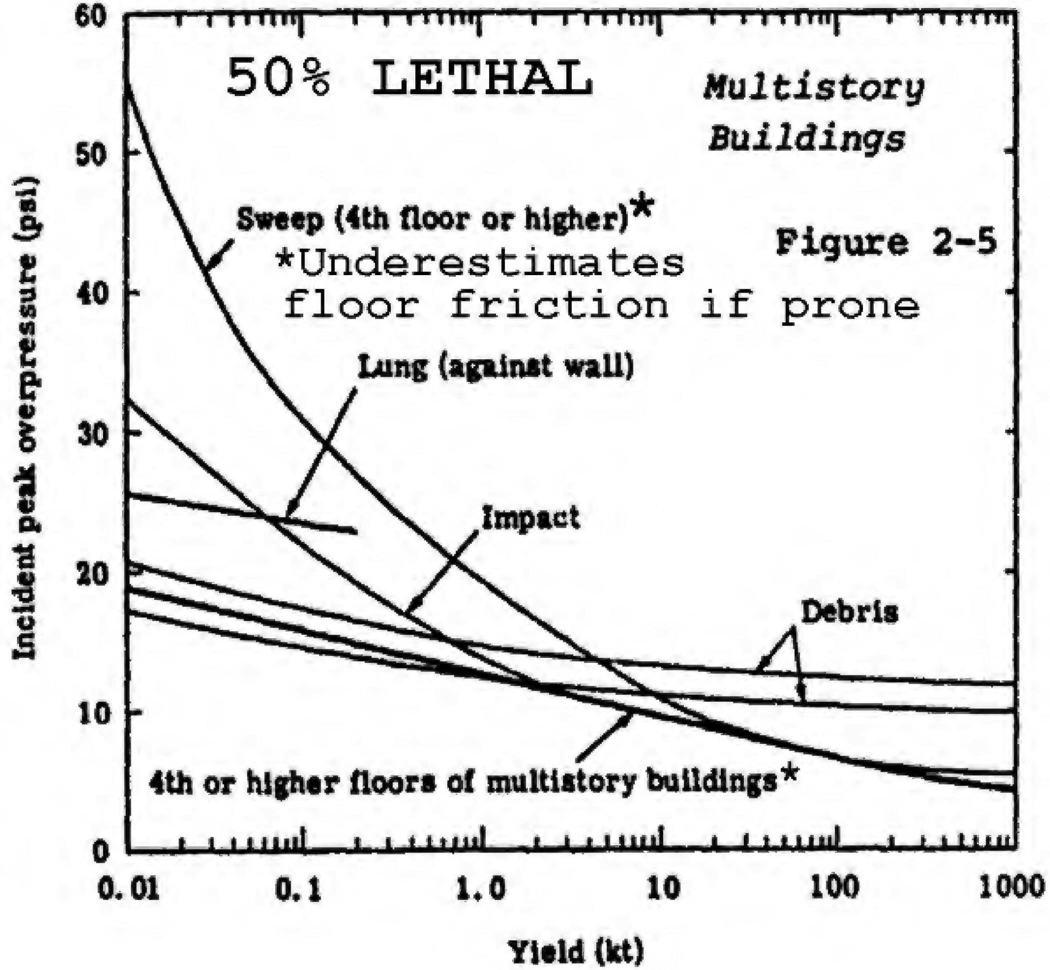
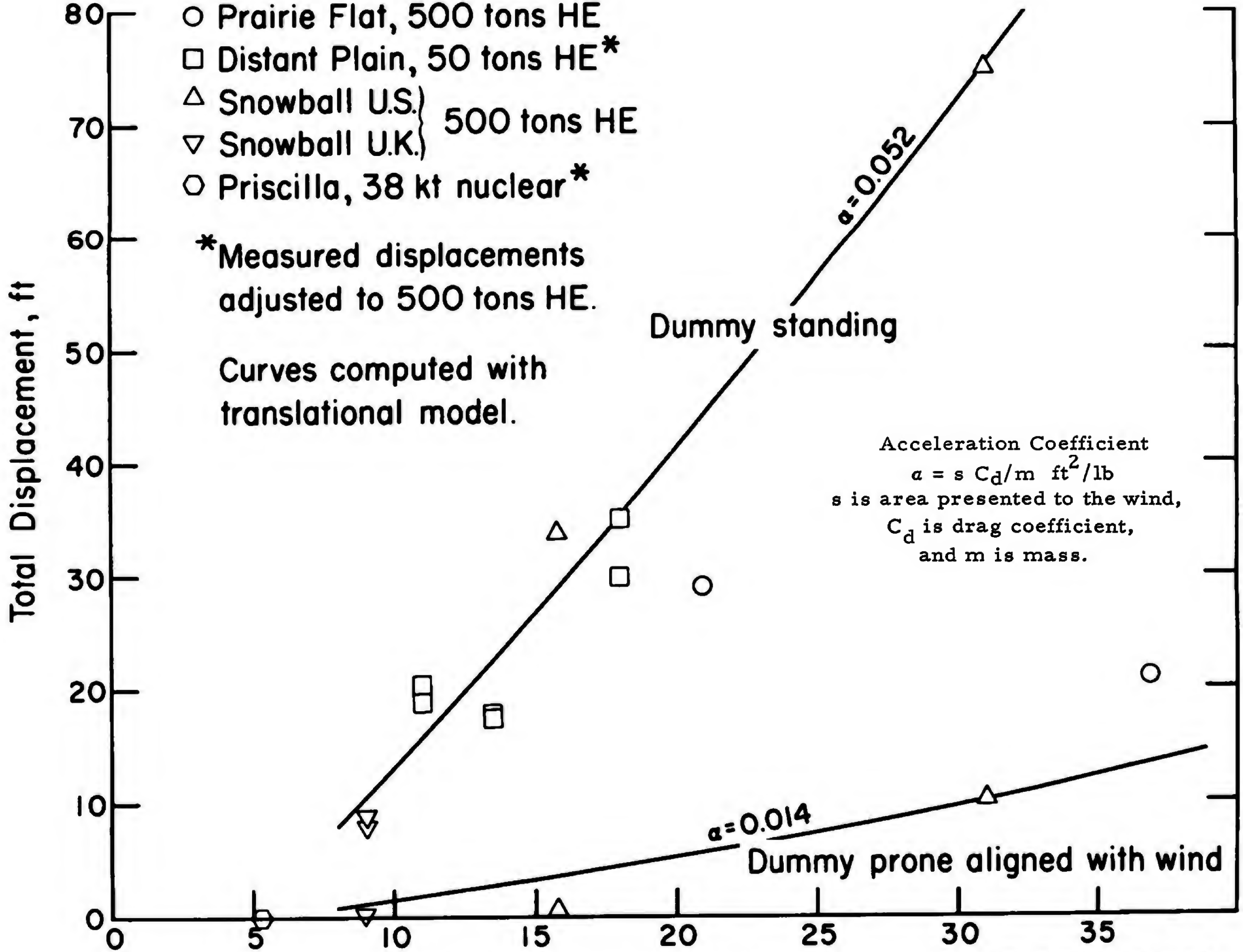
[1]USSBS, "The Effects of Atomic Bombs at Hiroshima and Nagasaki," p. 8.

[2]_Hiroshima_.

Dr Martin P. Fricke (Science Applications International Corp., California), "Preliminary Civilian Casualty Criteria for Low-Yield Nuclear Weapons," DNA-3547T, 1975.







○ Prairie Flat, 500 tons HE
□ Distant Plain, 50 tons HE*
△ Snowball U.S.
▽ Snowball U.K.
500 tons HE
⬡ Priscilla, 38 kt nuclear*
*Measured displacements adjusted to 500 tons HE.
Curves computed with translational model.
α=0.052
Dummy standing
Acceleration Coefficient
α = s Cd/m ft2/lb
s is area presented to the wind,
Cd is drag coefficient,
and m is mass.
α=0.014
Dummy prone aligned with wind
Total Displacement, ft
Peak Overpressure, psi
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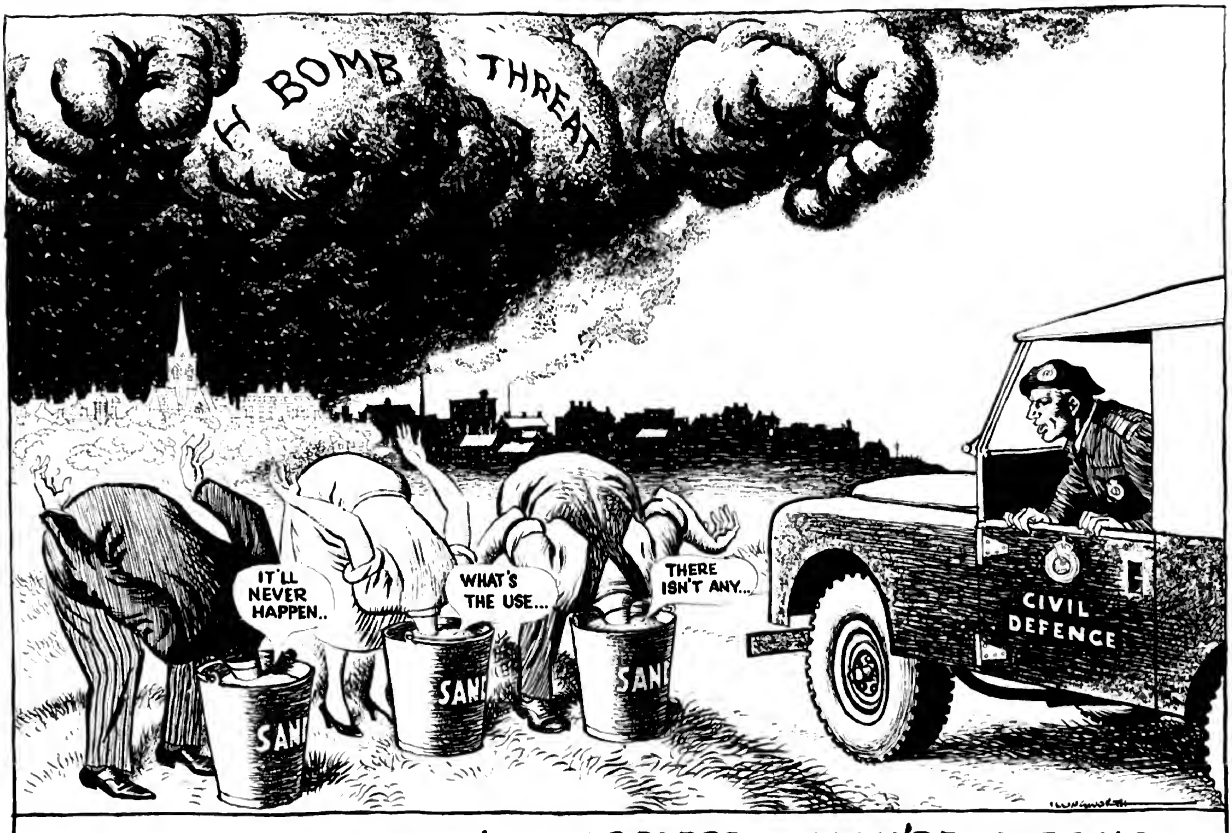


IF YOU THINK IT'S HOPELESS, YOU'RE WRONG

Specially drawn for H.M. Government by Illingworth

Cartoon by Leslie Illingworth

FOUR STRAIGHTFORWARD SIMPLE FACTS ABOUT

Civil Defence Today

The basic minimum of information for every responsible man and woman

1 The H-Bomb: we hear too much of the horrors, not enough about our chances of survival. Some people will tell you that if this country were attacked with H-Bombs, every man jack of the population would be wiped out. ***That just isn't true: it isn't anything LIKE the truth.***

There would be terrible devastation, but for millions and millions of people, chances of survival would be very good. It depends very much on our Civil Defence. The more people we have in it, the better.

2 Civil Defence is well on with the job already. Some people think of Civil Defence equipment as a long-handled shovel, a rather odd tin hat, and so on.

Well, it's not like that at all. Civil Defence today is a modern, country-wide Service, which offers you training with first-class equipment—radio and radiation-testing instruments, fire-fighting apparatus and rescue gear, and the latest four-wheel-drive vehicles. There are thousands of qualified Instructors, three full-time Instructors' Schools, and a Staff College for advanced courses and studies.

The more you get to know about Civil Defence, the more impressed you become.

There is a Civil Defence organisation in every town in the Kingdom, and there are units in thousands of industrial firms. There are *half a million* people in the Civil Defence Services today. But half a million is not enough: not nearly.

3 Civil Defence is useful to you now, in peace. In Civil Defence today, you *learn*. That is the whole aim and object of joining.

You learn, first and foremost, how to live with your eyes open in the same world as the H-Bomb. You begin to learn what this new, nuclear-age world is really like. You acquire a fuller, deeper understanding of many important events that we are all involved in, whether we like it or not.

Besides this, there is a practical, everyday value in the things you learn. Take just one part of it—First Aid. In Great Britain in 1956 there were over *a quarter of a million* casualties from motor accidents, and probably at least another *million* casualties from accidents in the home. What you know—or don't know—about First Aid could make all the difference to somebody.

Do you know how to put out a fire? Do you know how to operate a radio transmitter? These are two more of the useful, interesting things that Civil Defence could teach you, now.

Do you remember the East Coast floods, the Lynmouth disaster, the Harrow rail smash? These are three of the emergencies where trained volunteers from Civil Defence were ready and able to help. They were needed.

4 Civil Defence wants more volunteers, NOW. It's no good saying "I'll be there on the day." That's too late. There wouldn't be time to train you and organise you.

It's no good leaving Civil Defence to other people. For everybody else, *The Other Fellow is YOU.*

You live in this world, you are part of the nuclear-age—there is no opting-out for anybody. Civil Defence *matters*—and matters to YOU.

Go along to your Council Offices today, and ask about Civil Defence. There's no commitment, no 'bull', no length-of-service engagements.

Your training takes only about *one hour a week*. The classes are free, and are near your own home. The knowledge you gain could be useful to you at any time, and would be VITAL to you if we were at War.

Civil Defence is sound common sense. It's high time you were in it.

Civil Defence Recruiting Drives are going on now, all over the country. Their object is to tell you all about Civil Defence — what it can do, what it IS doing and what there is in it for you.


Warden Section


Headquarters Section


Ambulance and Casualty Collecting Section


Welfare Section

The FOURTH Arm

Traditionally, we have three Services in this country: the Royal Navy, the Army, and the Royal Air Force. Now, we have a fourth service of the Crown—unarmed, volunteer, part-time—but not less vital than the others: Civil Defence. We have peacetime Civil Defence for just the same reasons that we have a peacetime Navy, Army and Air Force: it is an essential part of our ordinary peacetime national preparedness. *That is all there is to it.*

WHAT YOU CAN DO IN CIVIL DEFENCE

Five Sections: *which will you join?*

WARDEN. This is a job for a man or woman with a quick, cool head and the power of leadership—and something of a flair for getting on with people. The Warden takes control of the area in an emergency and directs the other services where they are required.

HEADQUARTERS. This is the nerve-centre, where the reports come in and the orders go out. If you are an office or scientific worker, a radio 'ham', motor-cyclist or driver—here is interesting, important work that you could train for now.

RESCUE. Members of Rescue Squads are highly skilled. Each man carries a pack containing saw, wrecking-bar, lashings, wire-cutters and First Aid kit—and he is trained in the use of all of them. Backing up the Rescue Squad is a special Rescue Vehicle, with scaffold-poles, cables, winches, stretchers and heavy rescue gear. A rescue man needs intelligence as well as strength.

The **AMBULANCE AND CASUALTY COLLECTING** Section want two sorts of people—casualty collectors, to give First Aid and see that the injured get back safely to the ambulances — and drivers to take the ambulances back to hospital. This is work for both men and women—and if you drive a car already, so much the better.

The **WELFARE** Section would be called on first to help in bringing care and comfort to some millions of evacuees. But that is only the beginning of their job. After an attack, there would be more millions of people, to be housed, clothed, fed and kept healthy. Our very survival could depend on what the Welfare Section did then. The Welfare Section needs dependable, intelligent, capable men and women; and it needs them now.

AND THE AUXILIARY FIRE SERVICE, which also has really worth-while, practical training to offer. The work is important; a nuclear explosion sends out an intense heat-wave, and fires would be numerous and quick to spread. The A.F.S. has special nuclear-war fire-fighting apparatus: you would do your training with it.

IN EVERY SECTION YOU GET FIRST AID TRAINING


Rescue Section


Auxiliary Fire Service

CIVIL DEFENCE is common sense

Go to your Council Offices and ask, today. They will be glad to see you.

ISSUED FOR H.M. GOVERNMENT BY THE CENTRAL OFFICE OF INFORMATION

UK National Archives: INF 2/122 September 1957 national press advert

THE EFFECTS OF THE ATOMIC BOMBS AT HIROSHIMA AND NAGASAKI

REPORT OF THE BRITISH MISSION TO JAPAN

40. The provision of air raid shelters throughout Japan was much below European standards. Those along the verges of the wider streets in Hiroshima were comparatively well constructed : they were semi-sunk, about 20 ft. long, had wooden frames, and 1 ft. 6 ins. to 2 ft. of earth cover. One is shown in photograph 17. Exploding so high above them, the bomb damaged none of these shelters.

41. In Nagasaki there were no communal shelters except small caves dug in the hillsides. Here most householders had made their own backyard shelters, usually slit trenches or bolt holes covered with a foot or so of earth carried on rough poles and bamboos. These crude shelters, one of which is shown in photograph 18, nevertheless had considerable mass and flexibility, qualities which are valuable in giving protection from blast. Most of these shelters had their roofs forced in immediately below the explosion ; but the proportion so damaged had fallen to 50 per cent. at 300 yards from the centre of damage, and to zero at about $\frac{1}{2}$ mile.

42. These observations show that the standard British shelters would have performed well against a bomb of the same power exploded at such a height. Anderson shelters, properly erected and covered, would have given protection. Brick or concrete surface shelters with adequate reinforcement would have remained safe from collapse. The Morrison shelter is designed only to protect its occupants from the debris load of a house, and this it would have done. Deep shelters such as the refuge provided by the London Underground would have given complete protection.

LONDON

1946

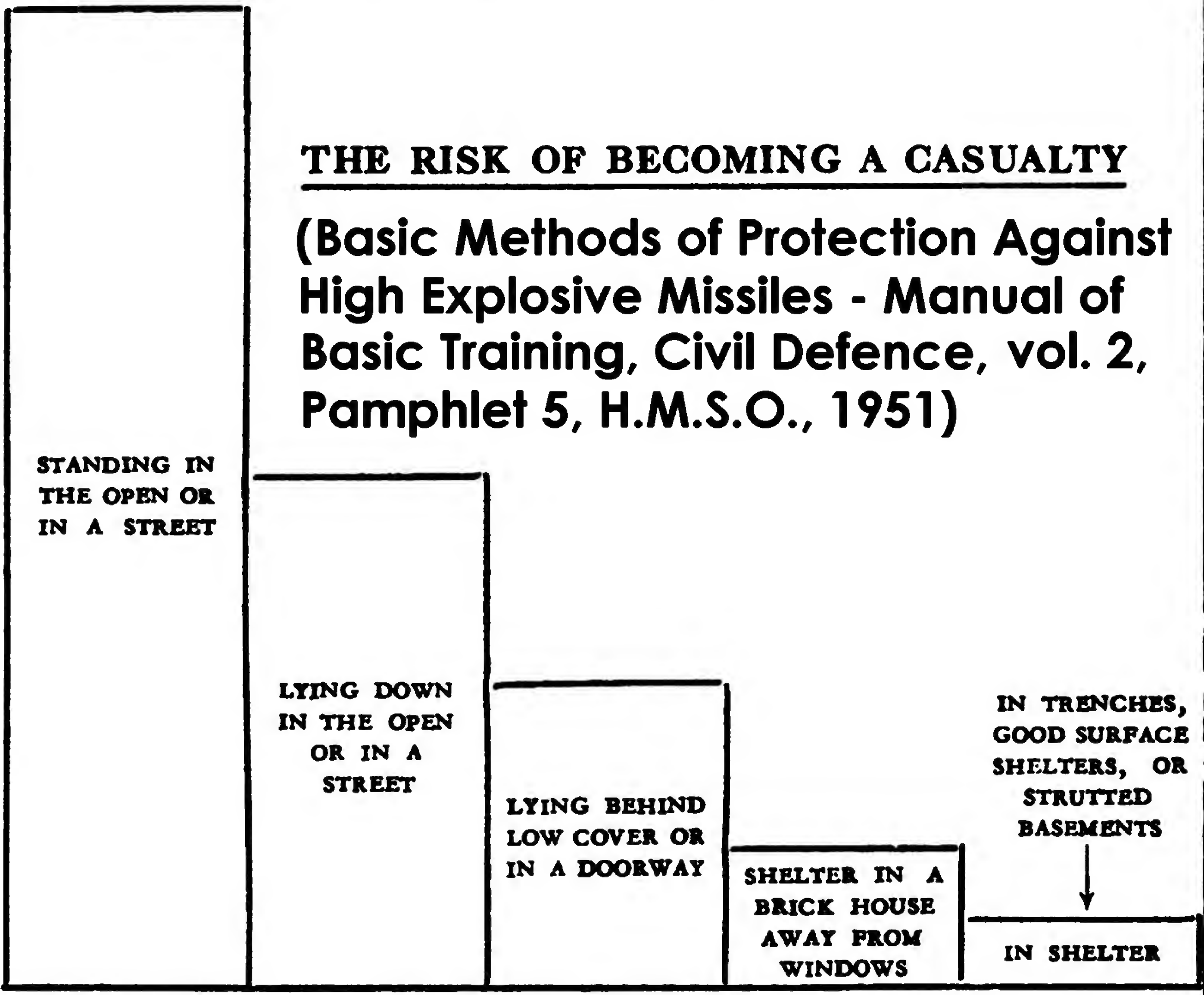
Photo No. 17. HIROSHIMA. Typical, part below ground, earth-covered, timber framed shelter 300 yds. from the centre of damage, which is to the right. In common with similar but fully sunk shelters, none appeared to have been structurally damaged by the blast. Exposed woodwork was liable to " flashburn." Internal blast probably threw the occupants about, and gamma rays may have caused casualties.

Photo No. 18. NAGASAKI. Typical small earth-covered back yard shelter with crude wooden frame, less than 100 yds. from the centre of damage, which is to the right. There was a large number of such shelters, but whereas nearly all those as close as this one had their roofs forced in, only half were damaged at 300 yds., and practically none at half a mile from the centre of damage.

It cannot be too strongly emphasised that it is most important, from the point of view of reducing casualties as a whole, for everyone in an area under attack to make use of any shelter that is available. Recent research has shown that there would be less fatal casualties if everyone were in relatively poor shelter than if half the population were in shelter twice as good and the other half remained in the open.

THE RISK OF BECOMING A CASUALTY

(Basic Methods of Protection Against High Explosive Missiles - Manual of Basic Training, Civil Defence, vol. 2, Pamphlet 5, H.M.S.O., 1951)



National Archives
HO197/24

Morrison Shelters in Recent Air Raids.

A report of Ministry of Home Security experts on 39 cases of bombing incidents in different parts of Britain covering all those for which full particulars are available in which Morrison shelters were involved shows how well they have stood up to severe tests of heavy bombing.

All the incidents were serious. Many of the incidents involved direct hits on the houses concerned a risk against which it was never claimed these shelters would afford protection. In all of them the houses in which shelters were placed were within the radius of damage by bombs; in 24 there was complete demolition of the house on the shelter.

A hundred and nineteen people were sheltering in these "Morrisons" and only four were killed. So that 115 out of 119 people were saved. Of these only 7 were seriously injured and 14 slightly injured while 94 escaped uninjured. The majority were able to leave their shelters unaided.

CD 2333

~~SECRET~~

HOME OFFICE

CD/SA 12
Copy. NO 5.

OFFICE OF THE CHIEF SCIENTIFIC ADVISER

A COMPARISON BETWEEN THE NUMBER OF PEOPLE KILLED PER TONNE OF BOMBS DURING WORLD WAR I AND WORLD WAR II

BOMB SIZES

=> ≈ 175 kg

For World War II the average bomb weight was between 150 - 200 kg. (R.C. 268, Table 6), whereas for World War I the majority of bombs were 12 or 50 kg.

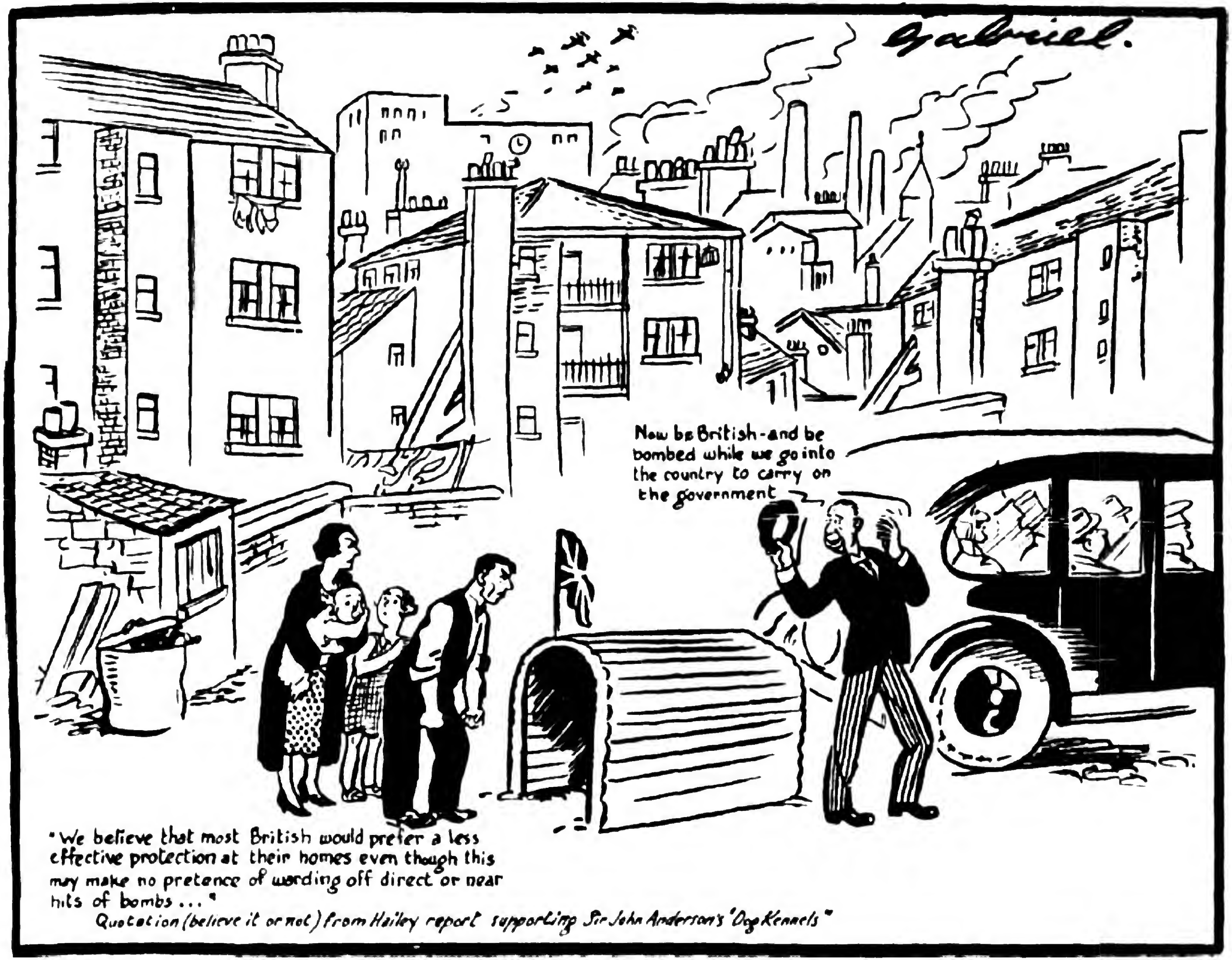
TABLE 5

Relative safeties in World War II deduced from population and casualty distribution

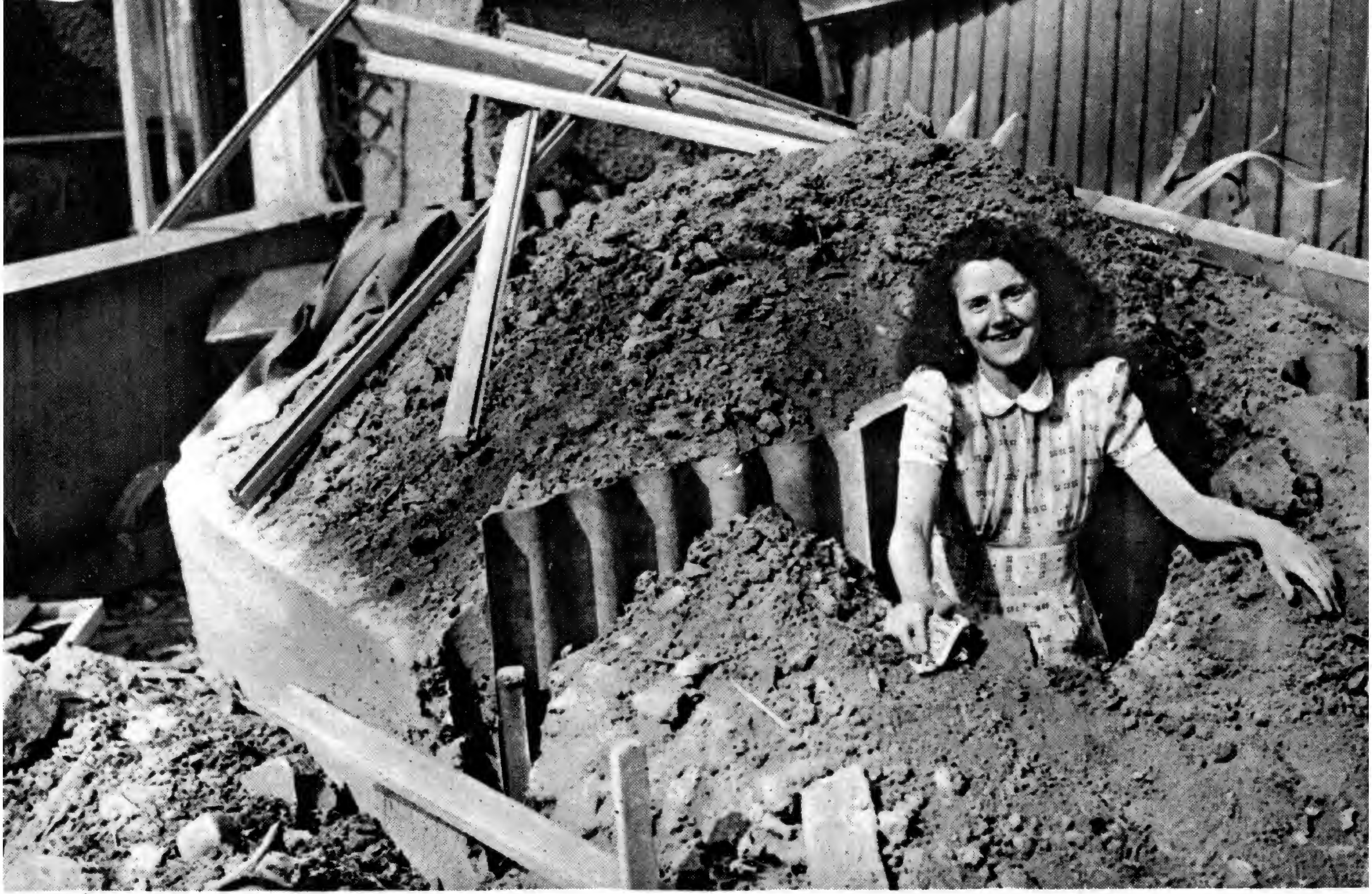
	In the open	Under cover	In shelter
Population exposure	5%	60%	35%
Location people killed	19%	62%	19%
Relative safety	72%	20%	10%
RELATIVE DANGER!			

(1) A house about $3\frac{1}{2}$ times as safe as in the open.
(2) A shelter about twice as safe as a house.

Table 6 also shows the location of killed which is implied by each of the possible population exposures. The only evidence available on this point is that, for the day raid on June 13th, 1916, in which the total number killed was 59, 69.5% of the people killed in the City were in the open.



IF WAR SHOULD COME!



ILLUSTRATED LONDON NEWS—Aug. 24, 1940

GIVING THE LIE TO GOEBBELS: MRS. E. CULLEN SMILINGLY LEAVING THE EMERGENCY EXIT—A BOMB HAVING BLOCKED THE SHELTER ENTRANCE. (*Planet.*)

ILLUSTRATED LONDON NEWS—Aug. 24, 1940

MR. AND MRS. SHERMAN, OF CROYDON, WITH THEIR BABY, BY THEIR SHELTER, ON EACH SIDE OF WHICH BOMBS BURST. (*G.P.U.*)

AFFORDING STRIKING PROOF OF THE EFFICACY OF ANDERSON SHELTERS:
ALMOST MIRACULOUS ESCAPES IN MIDLAND AND SOUTH OF ENGLAND HOMES.

AN ANDERSON SHELTER, CORRECTLY COVERED WITH EARTH (FROM WHICH CABBAGES SPROUT), UNHARMED DESPITE SURROUNDING BOMB DAMAGE. *Wide World.*

DAMAGED HOUSES, WITH AN UNTOUCHED ANDERSON SHELTER IN THE FOREGROUND, WHOSE OCCUPANTS FOUND COMPLETE SAFETY. *(Planet.)*

INTACT AMONG THE DÉBRIS CAUSED BY GERMAN BOMBS: AN ANDERSON SHELTER IN A S.-W. LONDON SUBURB. *(Planet.)*

TWO ANDERSON SHELTERS IN THE SAME DISTRICT AS THAT SHOWN IN THE PHOTOGRAPH ON THE LEFT, ALSO INTACT. *(Planet.)*

A LARGE BOMB-CRATER BEHIND A ROW OF DAMAGED HOUSES AFTER THE CROYDON RAID: THE SHELTERS WERE UNAFFECTED. *(Keystone.)*

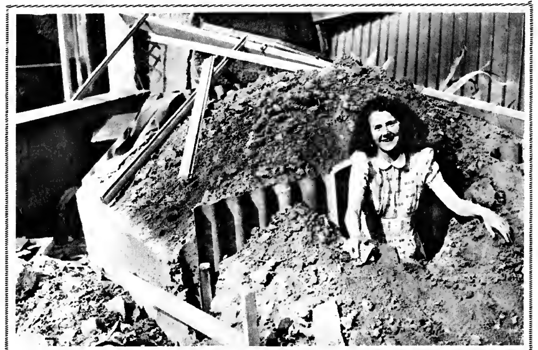
THE violent and very expensive raids by the *Luftwaffe* in the week ending August 17 provided a most reassuring demonstration of the efficacy of the Anderson shelter, when it has been properly covered with earth and the entrance adequately screened. Both at Croydon and in the Midlands its value was proved. When a bomb dropped in the middle of a triangle formed of three Anderson shelters in a Midlands town the occupants of all escaped unhurt. Seven people taking cover in a home-made shelter, however, were killed. Seven persons sheltering in an Anderson shelter in another Midlands area were unharmed by a bomb which exploded immediately outside it. When sixteen Nazi bombers were caught at Tilbury (Essex) between the A.-A. barrage and "Spitfires," they scattered and fled to sea with a vicious pursuit encouraging them. Six of their bombs fell on a housing estate. Four exploded harmlessly on grass verges, and two blew out the sides of a council house, but the occupants were in their Anderson shelter, less than ten yards away, and were unhurt. One man in South London, with his wife and two children, who had been evacuated from Folkestone, said that they were in an Anderson shelter during the raid on August 18 when five bombs fell within a distance of 100 yards. "Our little shelter trembled," he said, "but we suffered no shock and no damage, though our windows were broken." On the other hand, people in an Anderson shelter in the South-Western suburbs were injured by bomb splinters penetrating the back of the shelter, which was not completely covered with earth.

A CRATER, 25 FT. DEEP, OUTSIDE A DAMAGED HOUSE IN CROYDON. ALL THE OCCUPANTS OF THE SHELTERS ESCAPED INJURY. *(Topical.)*

HARDLY THE "COWERING" LONDONERS OF DR. GOEBBELS' IMAGINATION: A CHEERFUL NORTHFLEET FAMILY SITTING BY THEIR SHELTER AFTER A RAID. *(Fox.)*

AN UNDAUNTED MIDLAND FAMILY, DUG OUT AFTER A BOMB HAD BURST BEHIND THEIR SHELTER—WHICH SAVED THEM. *(A.P.)*

MR. AND MRS. SHERMAN, OF CROYDON, WITH THEIR BABY, BY THEIR SHELTER, ON EACH SIDE OF WHICH BOMBS BURST. *(G.P.U.)*



GIVING THE LIE TO GOEBBELS: MRS. E. CULLEN SMILINGLY LEAVING THE EMERGENCY EXIT—A BOMB HAVING BLOCKED THE SHELTER ENTRANCE. *(Planet.)*

15 Sept 1940: Anderson shelter occupants survived air raid, Ransome Way, Liverpool

Anderson shelter occupants survive air raid destruction at Purfleet

17 June 1944: Anderson shelter absorbs blast from V1 at Elsenham Rd, East End, London

Family survive without injury in wrecked Anderson shelter (note earth blown off) during London Blitz in 1940. Damage to the shelter absorbed the blast energy.

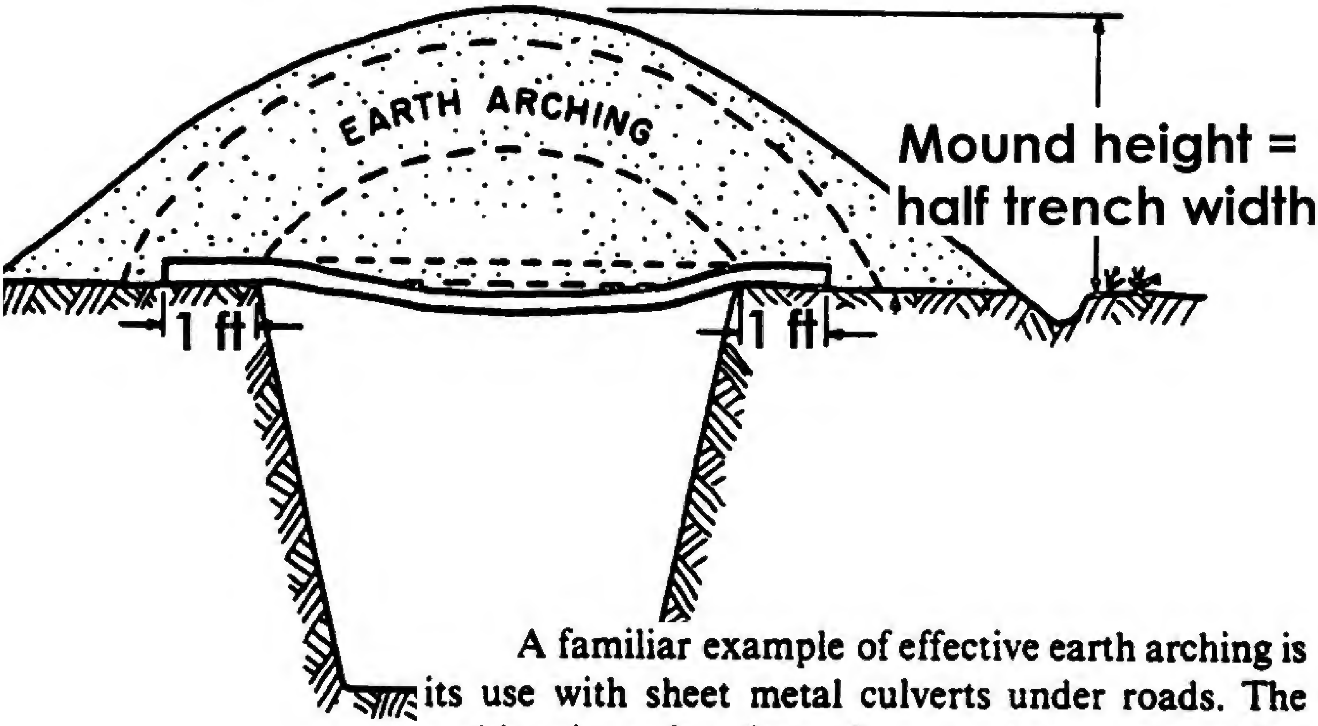
28 Jan 1945: Priory Road, East Ham

27 April 1944: Anderson shelter occupants survive at Forest Drive, East End, London

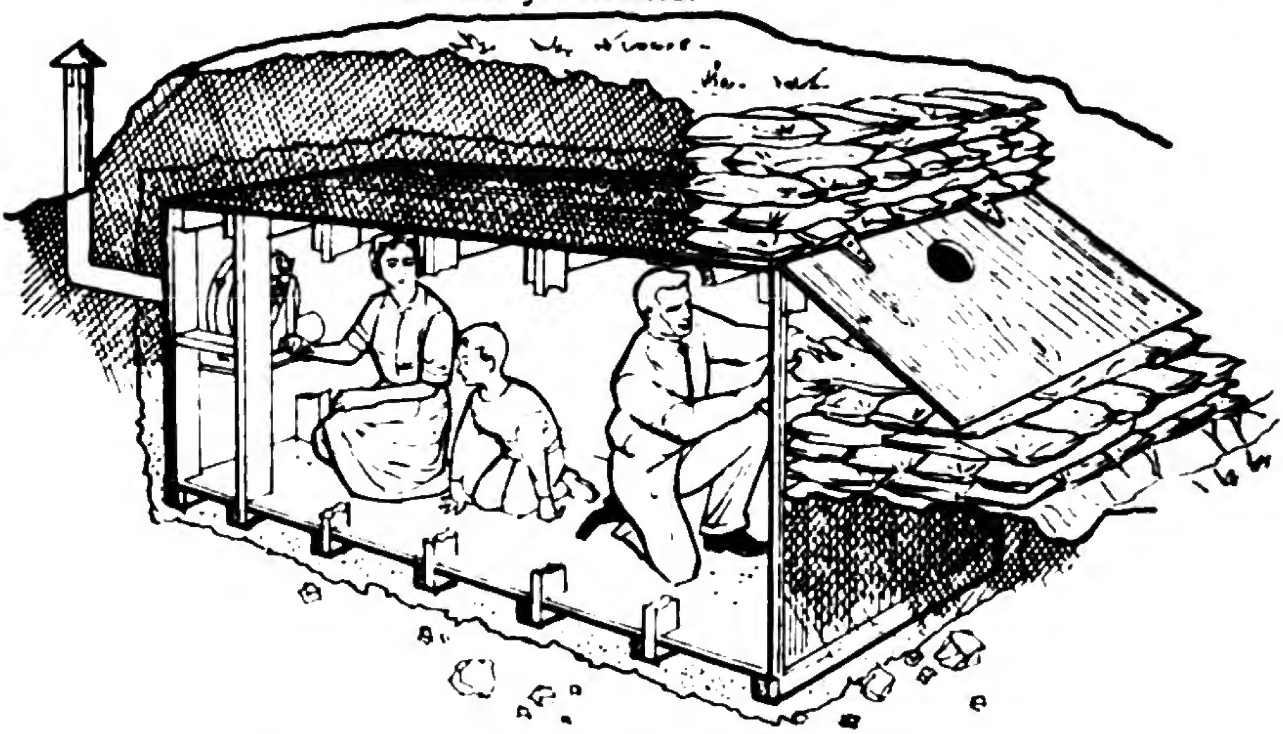
10 July 1944: Anderson shelter occupants survive air raid at Harcourt Avenue, East End, London

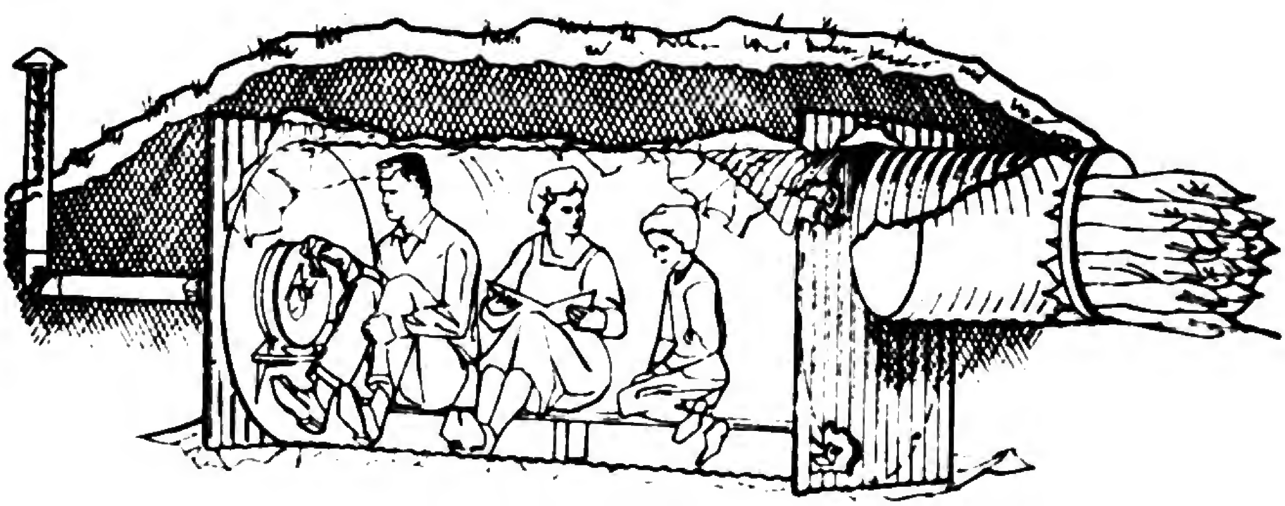
17 July 1944: Anderson shelter occupants survive at Tennyson Ave, Plashet Grove

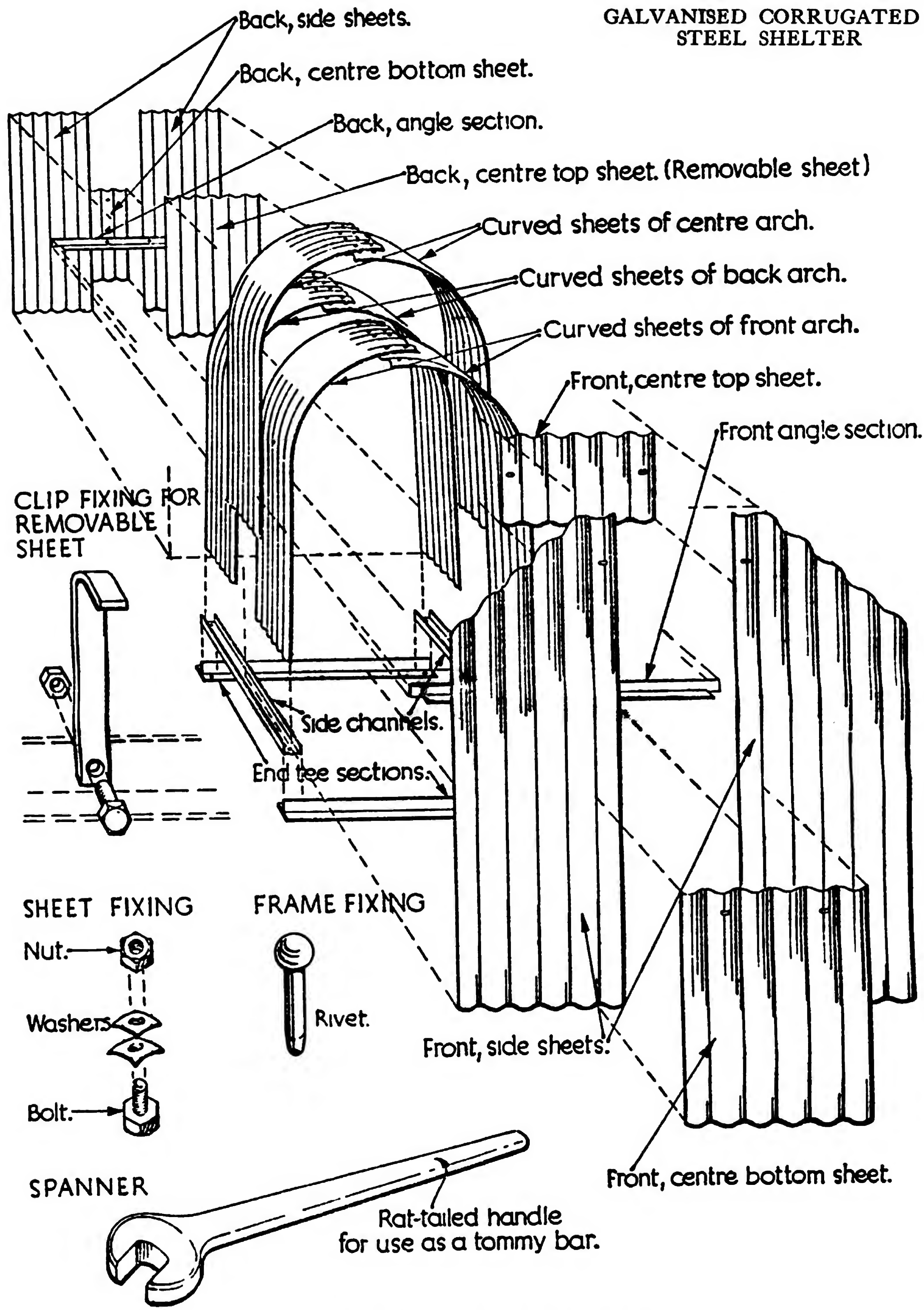
EARTH ARCHING USED TO STRENGTHEN SHELTERS



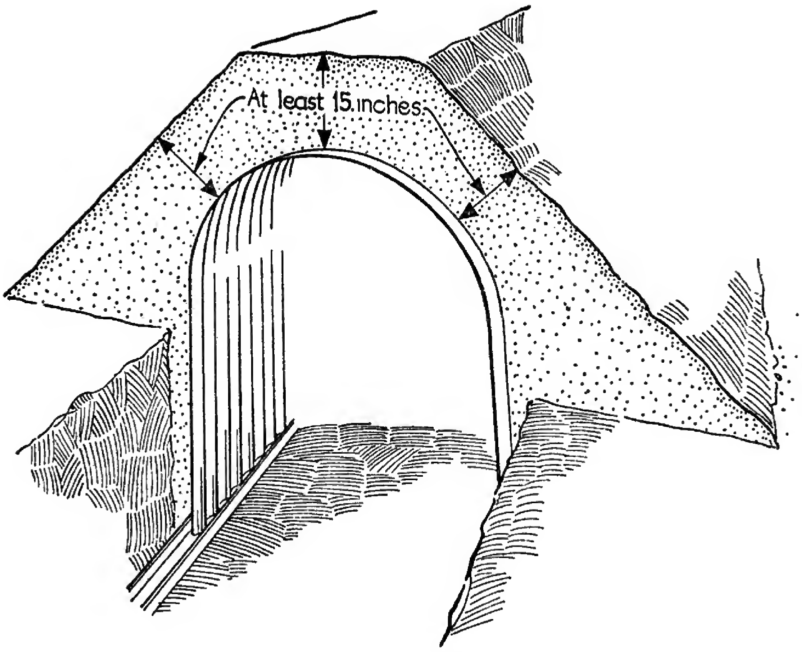
A familiar example of effective earth arching is its use with sheet metal culverts under roads. The arching in a few feet of earth over a thin-walled culvert prevents it from being crushed by the weight of heavy vehicles.



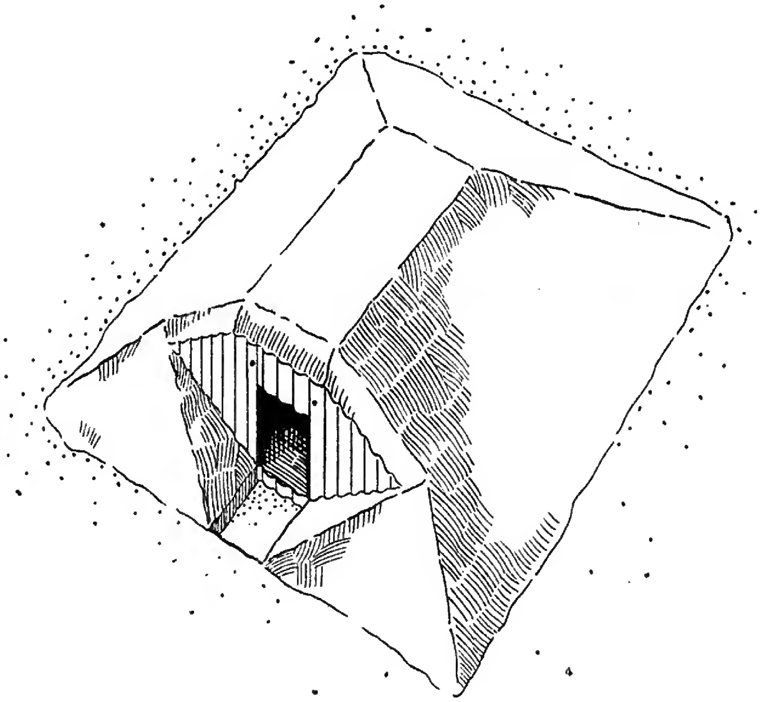




ANDERSON SHELTER



COVERING THE SHELTER WITH EARTH.


THE SHELTER COMPLETE WITH EARTH COVER.

Anderson shelter survives hit: Norwich 27 April 1942

Anderson shelter survives, Croydon, October 1940

29 July 1944: St Johns Rd, London, Mr and Mrs Dermott and Sgt Harrington

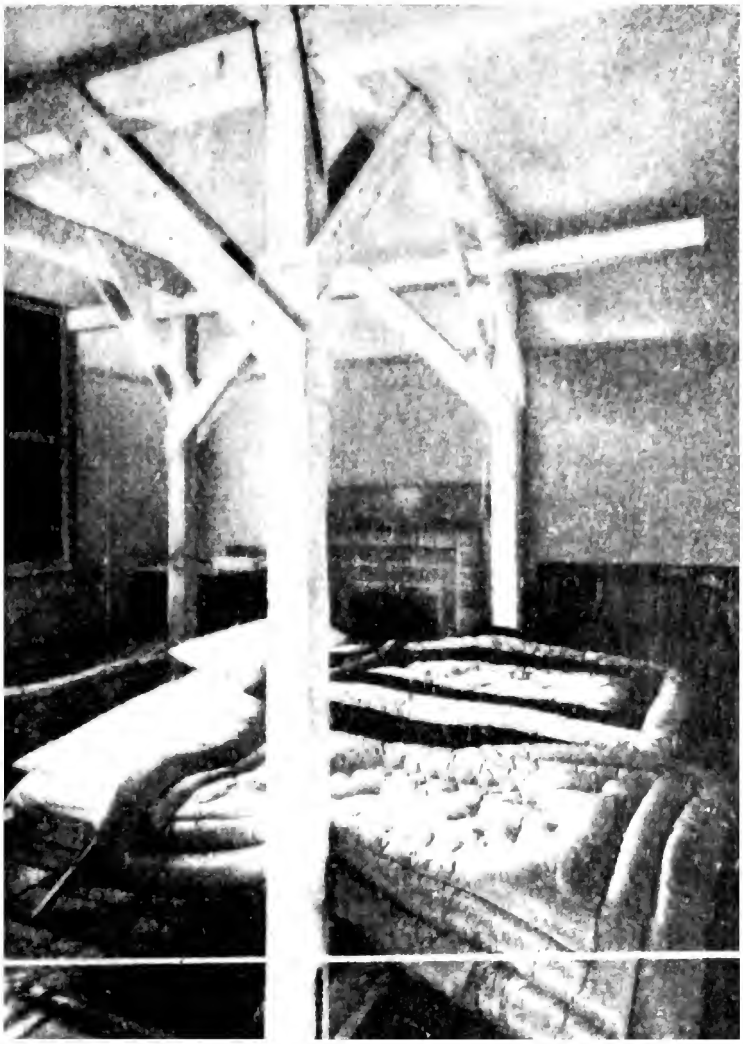
Anderson shelter beside crater (August 1940)

And They Came Out of It Alive . . .

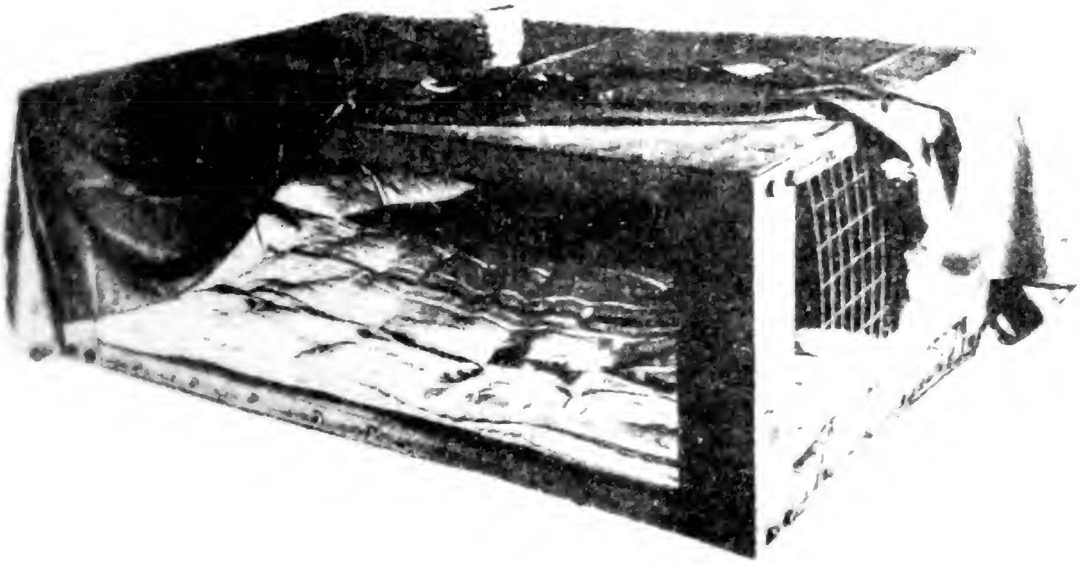
The edge of this bomb crater, 30ft. deep, in a household garden near London, is only 4ft. from the Anderson shelter. But the two people in the shelter during London's six-hour raid—Mrs. Clark and Miss Clark—were unhurt. You see Miss Clark in the picture examining the damage to the structure.

Daily Mirror
28 Aug 1940

June 1941



SHELTER at home



3d. ISSUED BY THE MINISTRY OF HOME SECURITY AND PUBLISHED BY H.M. STATIONERY OFFICE

Introduction

Not everyone wants to leave home for shelter. Some people can't. Lots of people just prefer to remain in their own house anyway. This inclination is a natural one. It is a sound instinct too, if some protection can be found against the collapse of walls and ceilings.

Shelter indoors allows you to sleep at night in reasonable security and in the warmth and comfort of your house. It also provides handy cover should there be a sudden raid in the day time.

A direct hit cannot be guarded against in any form of home shelter, but the risk of such a direct hit is very small compared with that of a bomb bursting near enough to damage the house or to demolish it. Protection can be obtained in a house even if a bomb demolishes most of it.

The walls, floors and roof of an ordinary house give quite a lot of protection against splinters and blast from a bomb. The idea of an indoor shelter is to make use of this protection and to add safeguards against the other effects of bombs.

The chief of these is the danger of the house falling down. People have often been rescued unhurt from the ruins of demolished houses because they had taken shelter under staircases, or tables, that had by chance been strong enough to protect them from the falling ruins of the house. The chief purpose of the indoor shelters described in this pamphlet is to protect the occupants against injury when the bedroom floor, the roof and other débris fall on them.

They do not provide such easy emergency escape as a garden shelter, but if you are trapped they protect you from the débris till the Rescue Party releases you. Very often, however, though the house has fallen you will be able to release yourself and walk out.

The indoor shelters with which this pamphlet deals are unsuitable for houses with more than two storeys above the shelter room. They are intended chiefly for use in ordinary two-storey houses, but have a margin of strength that will take the weight of an extra storey.

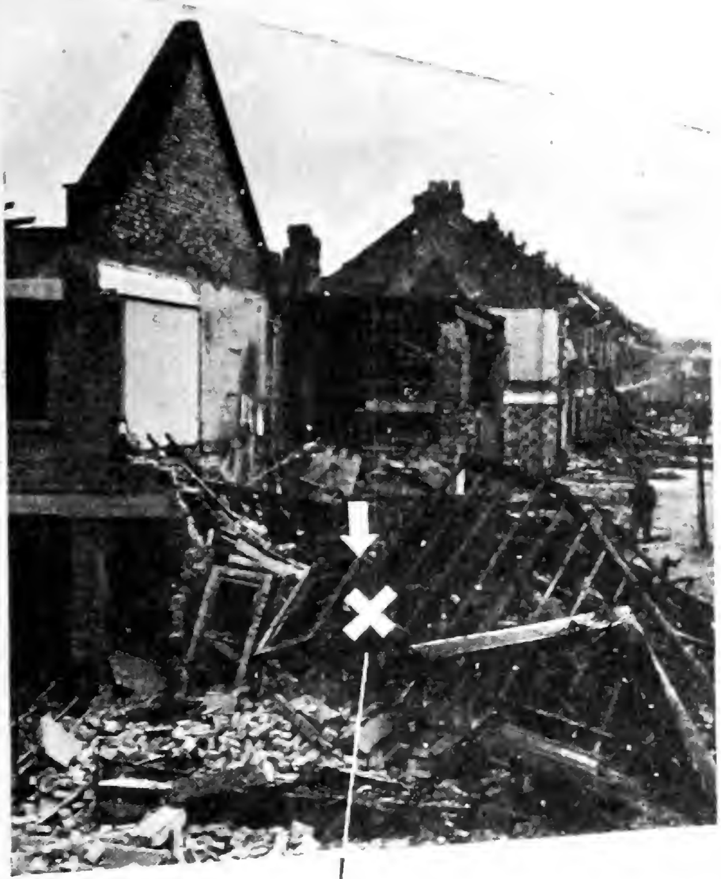
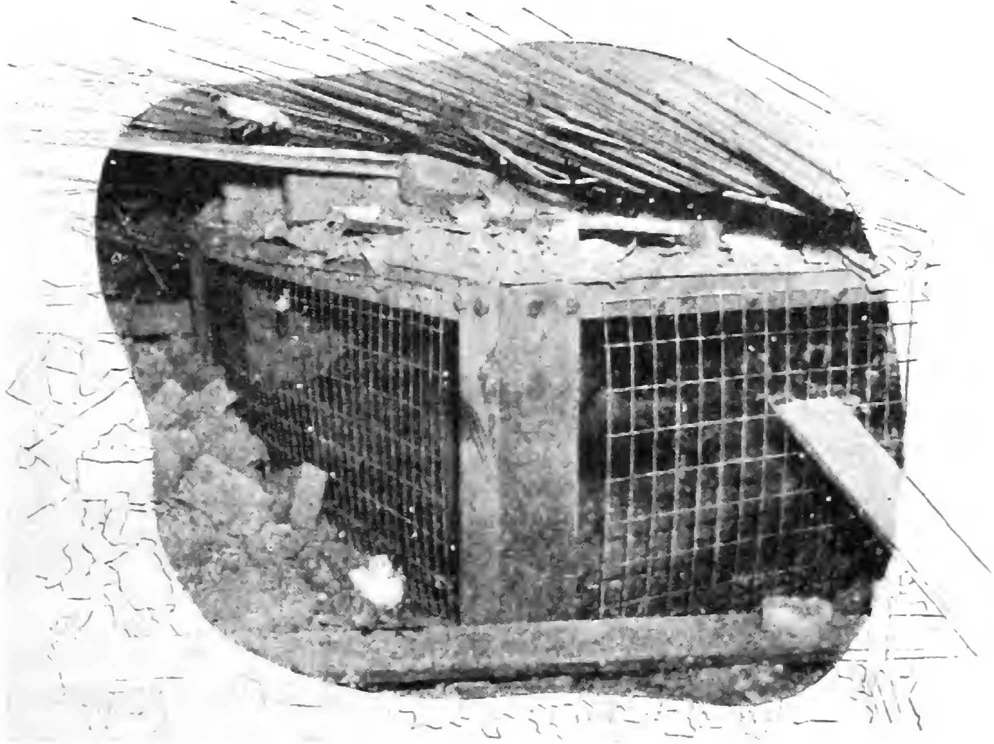


ILLUSTRATION NO. 8.

The house in the upper photograph had a Government steel table shelter in a downstairs room and was blown up to reproduce the effect of a heavy bomb falling near. The whole house collapsed, burying the shelter under débris. In the lower photo the shelter can be seen still intact. It would have been possible for anyone in the shelter to get out unaided.



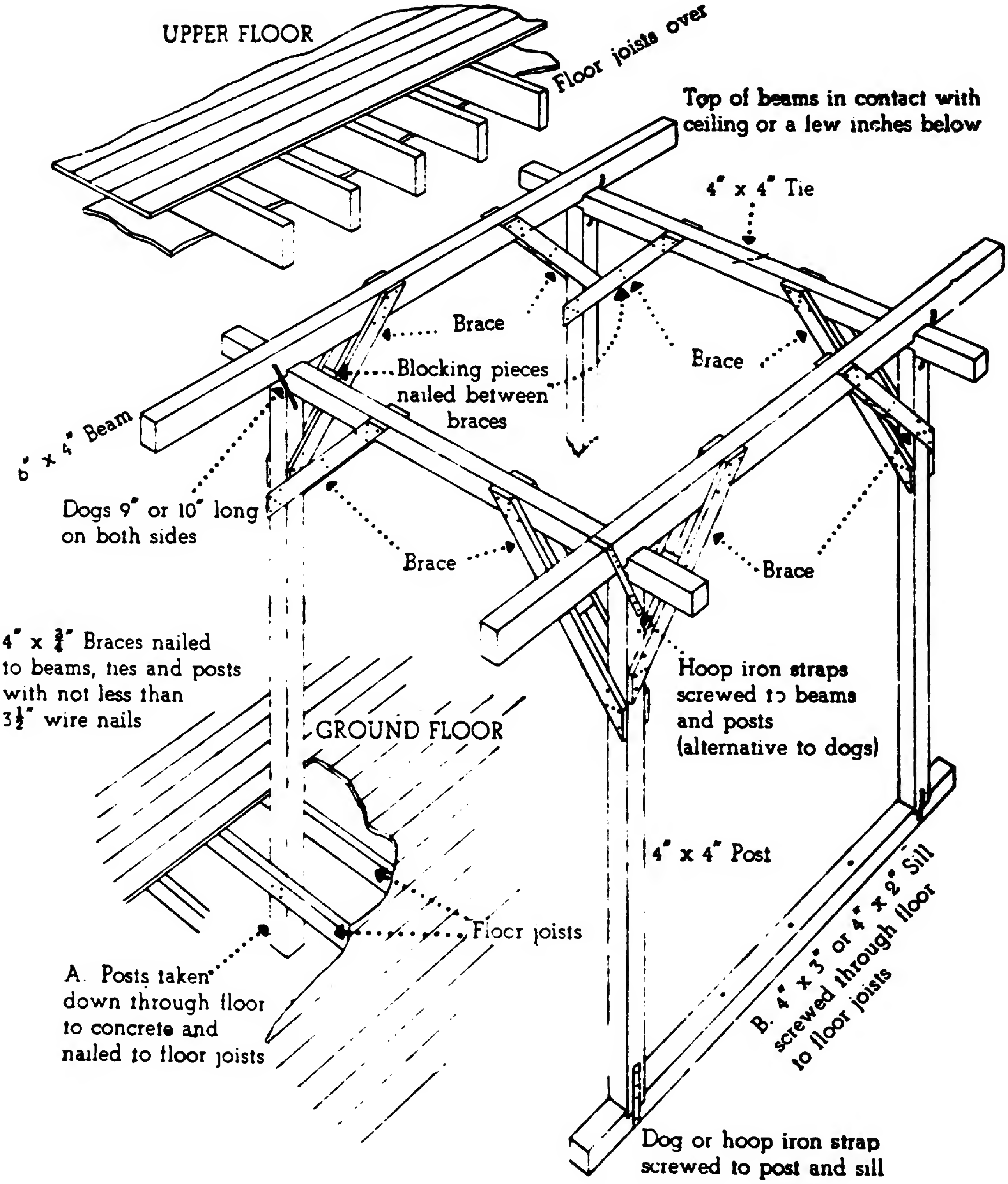
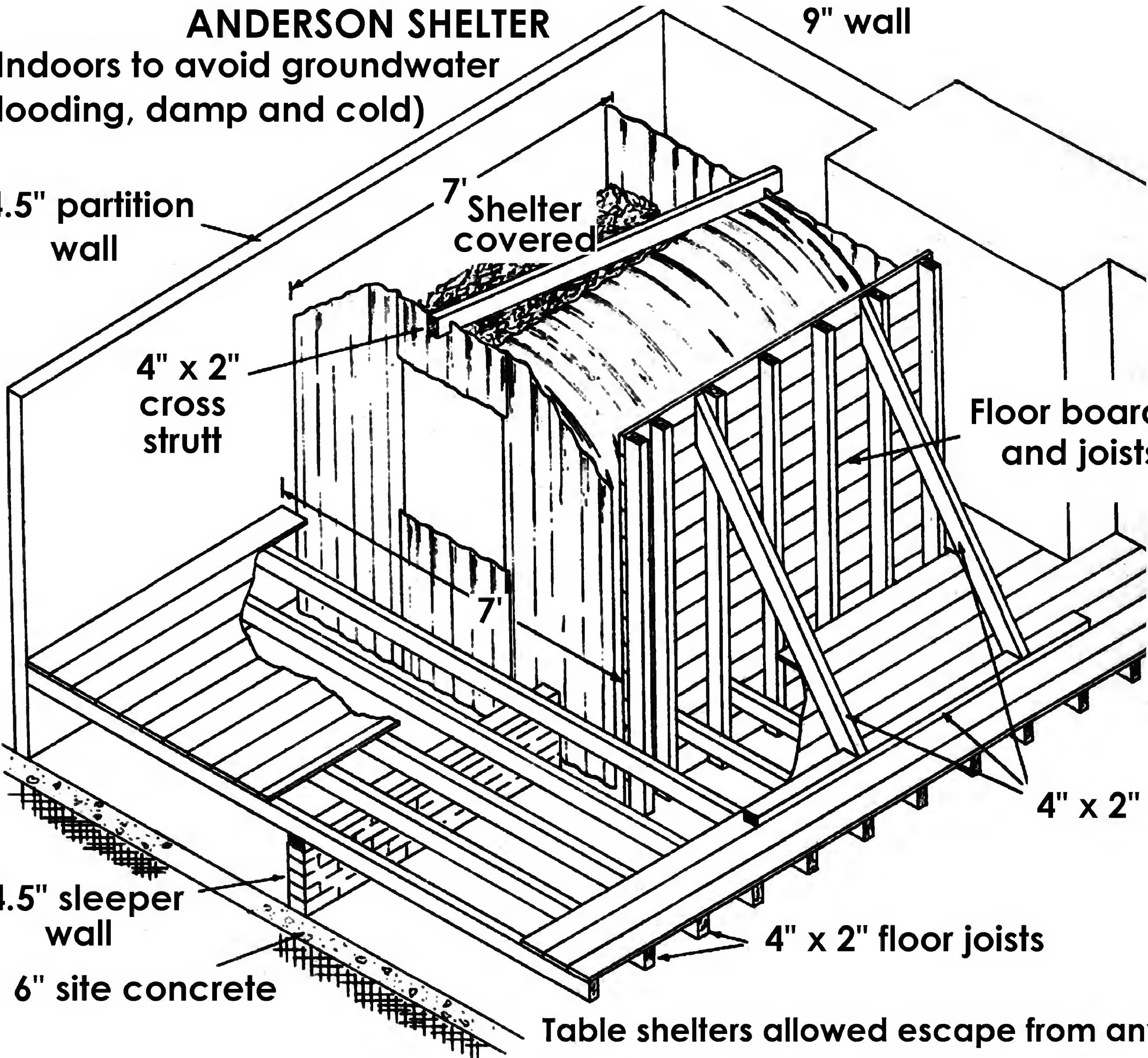


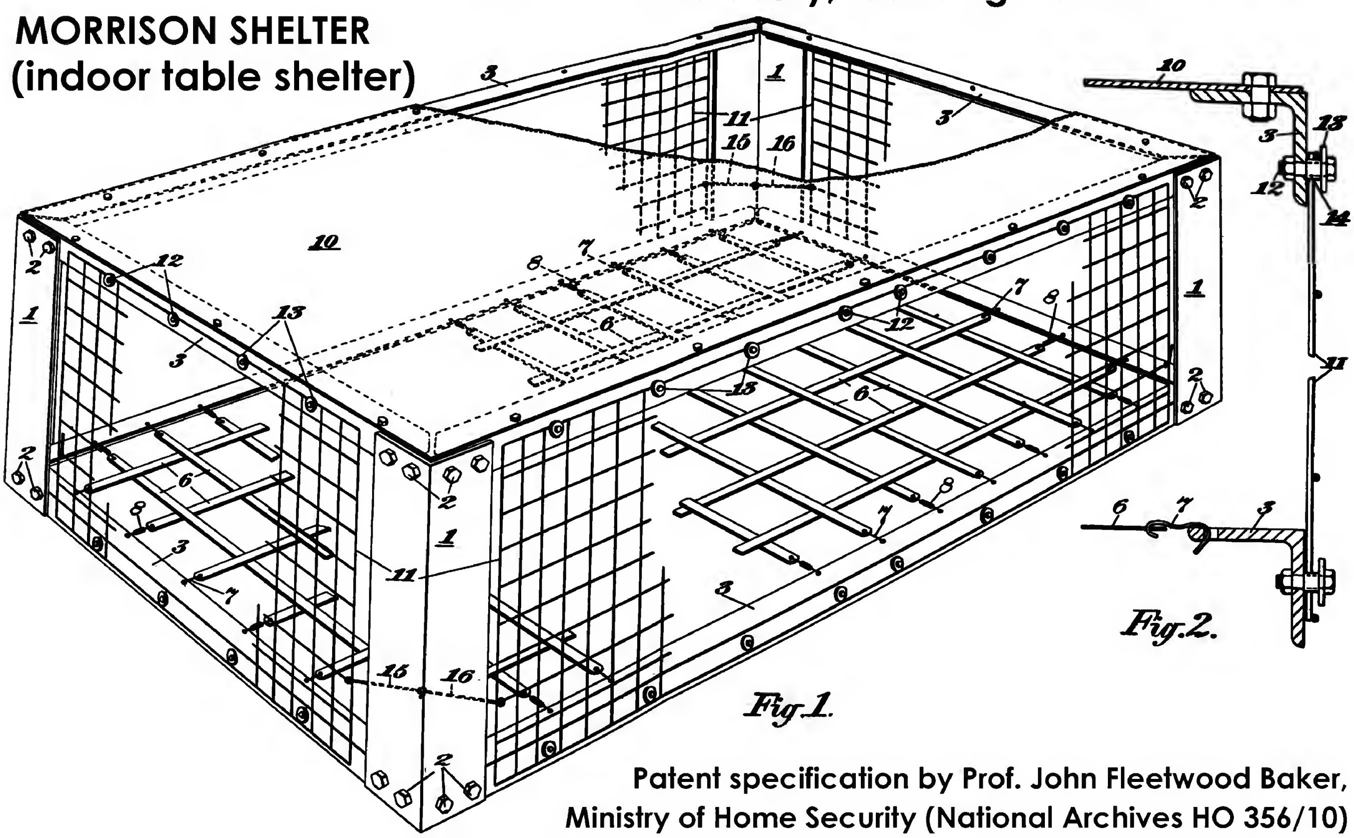
ILLUSTRATION NO. 11. Independent timber framework for a refuge room. If the posts are more than 6 ft. 6 in. apart, 8 in. × 4 in. beams are desirable.

A home-made shelter

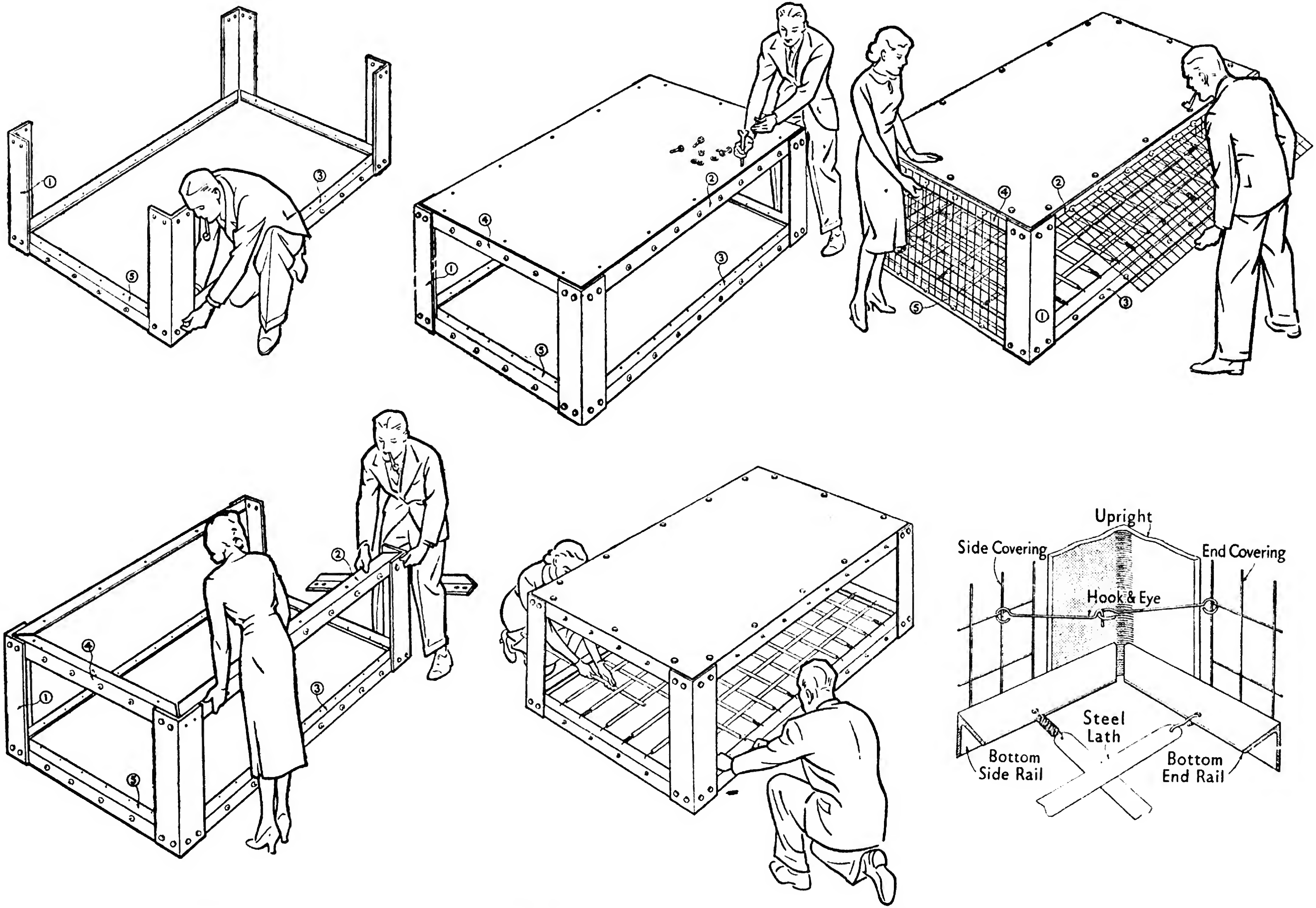
You will have noticed earlier in this booklet the statement that people have often been rescued from demolished houses because they had taken shelter under an ordinary table. This was because the table had by chance been strong enough to bear the weight of the falling bedroom floor. A timber framework can be built inside a refuge room to do the same thing, but with certainty. ILLUSTRATION NO. 11 shows a completed framework

November 1940 design by C. A. Joy, M. Inst. Me. & C. E., Bexley Borough Engineer (UK National Archives: HO 205/257)





Patent specification by Prof. John Fleetwood Baker, Ministry of Home Security (National Archives HO 356/10)



How to Put Up Your "Morrison" Steel Table Shelter, 1942

Structural Defense, 1945, by D. G. Christopherson, Ministry of Home Security, RC 450, (1946); Chapters VIII and IX (Confidential).
Chapter VIII summarizes the literature on the design and types of British shelters and analyzes their effectiveness.

National Archives
HO 195/16

(THIS DOCUMENT IS THE PROPERTY OF HIS BRITANNIC MAJESTY'S GOVERNMENT).

SECRET.

W.P.(G)(41)7. COPY NO. 62

January 15th, 1941.

WAR CABINET.

AIR RAID SHELTER POLICY.

Memorandum by the Minister of Home Security.

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6. Shelter in the home: The Anderson shelter was originally intended for indoor use but for a number of reasons including the danger of fire an outdoor variant was adopted. Experience has shown that the objections to the indoor use of the Anderson or somewhat similar shelter are not so serious as was thought and two designs have been produced which can be erected indoors without support. These new types, although they may give slightly less protection than a well covered Anderson shelter out of doors, would fill the needs of a large section of the public, especially the middle class. One design allows the use of the shelter as part of the furniture of the room.

7. I regard shelters of this type as of the first importance and wish to provide them on a big scale. Each shelter will use over 3 cwt. of steel and will allow at a pinch two adults and one to two children to sleep inside. For an outlay of about 65,000 tons of steel, as a first instalment, I could therefore produce 400,000 shelters with accommodation for at least 1,000,000 persons. I should wish to complete such a programme within the first three months of production and thereafter at a similar or increasing rate. From enquiries I believe that manufacture can be arranged provided steel is supplied and if the Cabinet approves my policy I shall require their direction that the steel be made available.

10. Conclusions.

I ask for a general endorsement of the policy I have outlined in this paper and in particular for the agreement of my colleagues:

(i) that proposals for building shelters of massive construction should be rejected;

(ii) that steel should be made available to carry out the programme outlined in paragraph 7 for the provision of steel shelters indoors;

(iii) that the limit of income for the provision of free shelter for insured persons should be raised from £250 to £350 per annum.

H.M.

MINISTRY OF HOME SECURITY.
January 15th, 1941.





ILLUSTRATION NO. 8.

The house in the upper photograph had a Government steel table shelter in a downstairs room and was blown up to reproduce the effect of a heavy bomb falling near. The whole house collapsed, burying the shelter under débris. In the lower photo the shelter can be seen still intact. It would have been possible for anyone in the shelter to get out unaided.

(Page 11 from the June 1941 UK Ministry of Home Security "Shelter at Home" handbook.)

Morrison indoor table shelter test by Ministry of Home Security, 1941: result shelter survived and occupants would have escaped unaided. (Source: "Shelter at Home", June 1941 handbook.)

Morrison shelter saves lives of Mr McGregor (pictured beside Morrison shelter), as well as his wife and lodger, in collapsed house, York 1942 air raid

Morrison shelter saves lives of Mr McGregor pictured beside Morrison shelter, as well as his wife and lodger, in collapsed house, York 1942 air raid

THE MANCHESTER GUARDIAN

18th February, 1954

DEVASTATION OF HYDROGEN WEAPON

Island Obliterated in U.S. Test

Chicago, February 17

The chairman of the Joint Congressional Atomic Energy Committee, Mr. Sterling Cole, hinted to-day that the United States might have hydrogen weapons even more potent than the experimental one which tore a crater a mile wide and 175 feet deep in the floor of the Pacific Ocean in 1952.

He said that the United States had "in being" an entire family of atomic weapons, some of them 25 times more powerful than the bomb that destroyed Hiroshima in 1945.

Mr. Cole gave details of the 1952 experiment in a speech at a commercial lunch here. He said:

"The thermo-nuclear test of 1952 completely obliterated the test island in the Eniwetok Atoll. It tore a cavity in the floor of the ocean - a crater measuring a full mile in diameter and 175 feet in depth at its lowest point. Within this crater, one could place 140 structures the size of our nation's Capitol.

If it occurred in a modern city, I am told that the heat and blast generated in the 1952 hydrogen test would cause absolute destruction over an area extending three miles in all directions from the point where the hydrogen device exploded.

This is an area of complete devastation - using the word 'complete' in its most precise meaning - six miles in diameter. The area of severe-to-moderate damage would stretch in all directions to seven miles from ground zero.

Finally, the area of light damage would reach to ten miles from the point of detonation. In other words, an area covering 300 square miles would be blanketed by this hydrogen explosion."

Because of what he called "the appalling meaning of the hydrogen bomb." Mr. Cole said that "it is not enough to notify an enemy that the attempted destruction of our own cities would be automatically answered by the destruction of his."

"Atom-Rattling"

Mr. Cole said that security prevented him from commenting on where "our hydrogen weapons programme now stands and from outlining the directions in which it is now moving, but I can assure you that it is moving." He felt that "it is more sinful to conceal the power of the atom than to reveal it."

10 megatons Mike (1952) won't fit in MIRV warheads!

Leader-Republican

GLOVERSVILLE AND JOHNSTOWN, N. Y., WEDNESDAY, FEBRUARY 17, 1954

Rep. Cole Hints America Possesses Super H-Bomb

Claims It 'Sinful' To Conceal Power Of Nuclear Project

Much Progress Made Since 1952 Blast Which Obliterated Test Island at Eniwetok, Tore Mile-Wide Ocean Hole

CHICAGO (AP)—A congressional atomic specialist hinted today the United States may have hydrogen weapons even more potent than a device that nearly 18 months ago tore a hole a mile wide and 175 feet deep in the floor of the Pacific Ocean.

Rep. W. Sterling Cole (R-NY), chairman of the Senate-House Atomic Energy Committee, gave details never before discussed publicly of a 1952 thermonuclear test in the Marshall Islands. President Eisenhower has termed that test a first step in the nation's hydrogen program.

Cole said in a speech prepared for a joint luncheon of the 38th annual National Sand and Gravel Assn. convention and the 24th annual National Ready Mixed Concrete Assn. convention:

Wiped Out Island

"That thermonuclear test of 1952 completely obliterated the test island in the Eniwetok Atoll.

"It tore a cavity in the floor of the ocean—a crater measuring a full mile in diameter and 175 feet in depth at its lowest point.

"Within . . . this crater, one could place 140 structures the size of our nations capitol."

If this blast had been touched off in a modern city, Cole said, the resultant heat and blast would have completely devastated an area three miles in all directions from the point of explosion.

Much Destruction

In all, he said, the 1952 blast would have blanketed an area of 300 square miles.

But this test was held almost a year and a half ago, Cole said, and he added:

"Security keeps me from commenting on where our hydrogen weapons program now stands, and from outlining the directions in which it is now moving. But I can assure you that it is moving."

Cole said he feels "it is more

Cut In Supports Could Hike Milk Consumer Costs

Dairy Economist Fears 1.5 Cent Boost Per Quart

SYRACUSE (AP) — The forthcoming cut in federal price supports on butter, cheese and dried milk could result in a 1½-cent, per-quart boost in the retail price of fluid milk in New York State, a dairy economist says.

John C. York, economist for the Eastern Milk Producers Cooperative Assn., reasons this way:

When price supports at 75 per cent of parity become effective April 1, each dairy farmer in the state probably will get 25 to 30 cents less per hundredweight (about 47 quarts) for the milk he sends to market.

If farmers were to get back on milk sold for bottling the money lost on milk sold for butterfat and manufacturing, consumers eventu-

Ike Requests A-Sharing With Allies

Would Cover Data For Battlefield, Peacetime Uses

WASHINGTON (AP) — President Eisenhower asked Congress today for authority to share limited information on battlefield use of atomic weapons with friendly nations.

In a special message, the President also asked for the right to share peacetime atomic power production information with this country's allies and to give American private industry a greater share in the development of nuclear power.

Eisenhower said these steps would have the effect of "strengthening the defense and the economy of the United States and of the Free World."

The President said the onward rush of atomic developments has outmoded the 1946 Atomic Energy Act which mistakenly assumed the United States could maintain a monopoly in atomic weapons for an appreciable time.

Wide Variety

Counterbalancing the loss of monopoly, he said, is the development of a wide variety of atomic weapons which have "achieved conventional status" in the armed forces.

He said with emphasis, however, that changes should "make it clear that the authority granted must be exercised only in accordance with conditions prescribed by the President to protect the common defense and security." And he stressed that no secrets are to be given away which would be of military advantage to potential enemies.

Cannot Help Out

Under present law, the President said, this country cannot give its allies "practical information essential to their effective participation with us in combined military operations and planning, and to their own defense against atomic attack."

Plattsburgh Press-Republican

Your "Good Morning" Newspaper Serving The North Country

161. Member of The Associated Press Plattsburgh, New York, Thursday, February 18, 1954 Telephone: Plattsburgh 77

Cole Hints H-Bomb More Destructive

CHICAGO, Feb. 17 (AP)—A congressional atomic authority hinted today that the United States may have increased the destructive potential attained in its first full-scale hydrogen explosion and is working toward development of a versatile line of hydrogen weapons.

Rep. W. Sterling Cole (R-NY) revealed officially for the first time that the 1952 thermonuclear test in the Marshall Islands completely obliterated the test island in the Eniwetok Atoll and gashed a crater in the ocean floor a full mile in diameter and 175 feet deep at its lowest point.

He said the explosion crater was large enough to hold 140 structures the size of the nation's capitol.

Cole said Russia soon will have the capacity to hit the United States with a crippling hydrogen and atomic blow. But, he added, it's "entirely within our capacity" to produce "tens of thousands" of atomic anti-aircraft defensive missiles as "a barrier of atomic firepower."

Cole, chairman of the Senate-House Atomic Energy Committee, said the 1952 American hydrogen blast, if exploded over a modern city, would have:

Blanketed an area covering 300 square miles.

Created an area of complete devastation six miles in diameter.

Spread moderate to severe damage seven miles in all directions.

Resulted in damage as far as 10 miles from the point of explosion.

RESTRICTED

HOME OFFICE,
Civil Defence Department,
Intelligence Branch.

Date of Issue: 14th January, 1955.

CDI 5/902

C.D. INFORMATION BULLETIN NO. 1/1955

Subject: Publicity given in the United States of America to Radioactive Fall-out

EARLY IMPRESSIONS

By way of introduction we can say that the radioactive effect of atomic weapons has been of continuing interest to the American public since the first atomic bombs were dropped in 1945. Americans, having become fairly used to the idea of radiation, took no more than a passing interest in the story of the crew of the Japanese fishing boat "The Fortunate Dragon" and of the Marshall Islanders who experienced a noxious fall-out during the Pacific tests in the Spring of 1954. What was not known or expected, however, was the strong probability that the wide-spread fall-out of noxious particles was no mere accident but an inherent characterestic of the new kind of hydrogen bomb. Official sources, apart from commenting on the increased power of the bomb, gave no hint of this but rather stressed the twin characteristics of heat and blast, particularly the first of these. Furthermore, the impression given was that intensive radioactivity might be achieved only by using a cobalt layer to form active cobalt dust.

PUBLIC STATEMENTS BY U.S. SCIENTISTS

Early in October, Dr. Lapp one of the men who helped develop the atom bomb and now Director of the Nuclear Science Service, deprecated in a public statement the atomic secrecy which prevented American Civil Defense telling the facts. Later in October, Dr. Lapp, in a public speech said that shelter of 20-30 ins. of hard-packed earth overhead would be sufficient to protect against a fall-out and suggested that one should stay in such a shelter for at least a day after the fall-out had ended. "The decay is rapid" he said.

"How long a fall-out area would be uninhabitable for permanent occupancy is something that needs a lot of study. The Government should come out in the open, face this problem and find the answers".

New York Post editorial of December 14 took note of rumours published in the Japanese press as to the seriousness of injuries to accidental victims of the world's first H-bomb explosion, making the point that the subject of radiation "is surrounded with the strictest kind of hush-hush......... It is entirely possible that the data now at hand is inconclusive. But surely it is time for official candor. In the absence of candor the scare will spread. If there is any evidence indicating that humanity is slowly crippling itself by playing around with nuclear weapons, it can hardly be long suppressed. There is every reason for an authoritative statement from the White House now as to what we know - and don't know - about this ghoulish topic."

Chairman Lewis L. Strauss of the A.E.C. said on December 15, that the U.S. was "making very rapid and satisfactory progress" and continued to lead Russia in the nuclear weapons field. He made the statement in a copyrighted interview with the magazine U.S. News and World Report. Strauss also was asked whether the world was getting more radioactive as more and more atomic tests are conducted. The A.E.C. Chairman replied, "Yes, but not significantly," and he added: "Ever since the first atomic bomb was tested .... infinitesimal amounts of radioactivity have been distributed around the world. I am advised by those who know that the radiation dose from fall-out is many times less than the dose rate due to cosmic rays." (AP-Wash. Star, U.S. News and World Report) ...... A.E.C. Chairman Strauss took the optimistic view about the outcome of nuclear warfare. Offering his views as the adult guest on the New York Times Youth Forum, Strauss said he did not believe such warfare would destroy the earth or civilization. "I believe that man will control the atom long before he learns to control himself."

~~Secret~~

Interagency
Intelligence
Memorandum

CIA HISTORICAL REVIEW PROGRAM
RELEASE AS SANITIZED

Soviet Civil Defense

~~Secret~~

NIO IIM 76-041
November 1976

Copy № 404

— *Basement*—shelters created by adapting the basement areas of residential, government, and industrial structures, primarily for protection against fallout. (See Figure 12.)

— *Subways*—shelters provided by using the subway tunnels in major Soviet cities. The degree of protection against blast varies within subways, but all afford good protection against fallout. (See Figure 13.)

— *Expedient or hasty*—shelters built with materials readily available during the period immediately prior to a nuclear attack. (See Figure 14.)

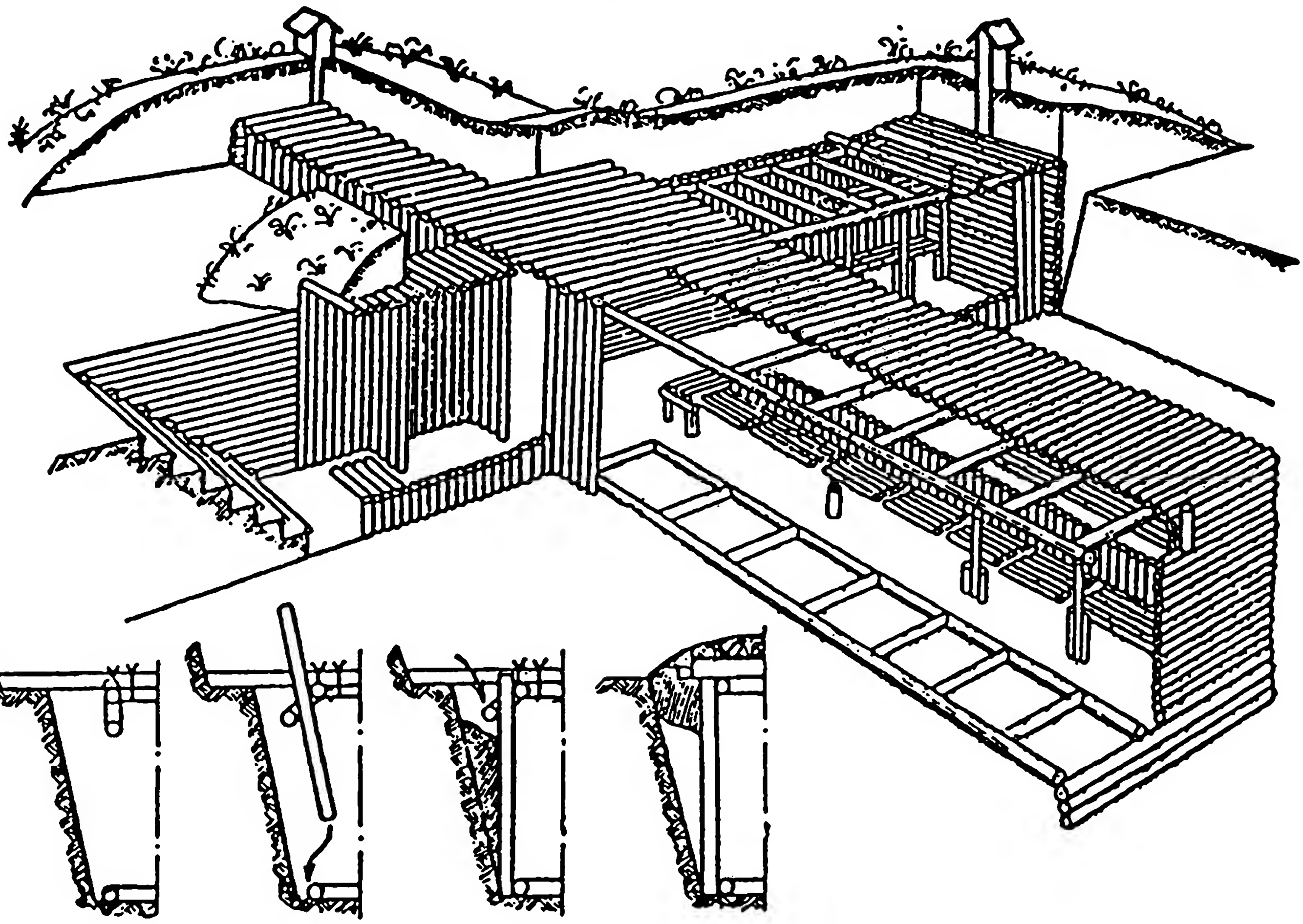
112. These several types of Soviet shelters offer varying degrees of protection against blast and fallout. According to Soviet planning, the type of shelter, its location, and the protection afforded are functions of the priority assigned to the survival of the protected personnel, the likelihood of direct attack or proximity to a target, and the availability of suitable structures that could be adapted as shelters.

113. Detached, bunker-type shelters, adaptable and built-in basement shelters, and subways are available for the protection of both essential workers and the general population. Dual-purpose shelters are also used as underground garages, clubs, and theaters which could be converted quickly to civil defense use.

114. Soviet writings and human sources have also referred to the use of various types of expedient, or temporary, shelters for protection from fallout. They consist of trenches lined with readily available materials and covered with earth. These shelters, which are described in more detail in paragraphs 139-141, are intended primarily for use by the rural population and by the urban population at dispersal and evacuation sites in rural areas. They could also be

Figure 14. Illustration of Soviet Expedient or Hasty Shelter

Diagrams such as this are provided in manuals widely distributed to the Soviet population for use in constructing hasty shelters in dispersal and evacuation areas.



569821 6 76

[USSR, "Antiradiation shelters in rural areas", 1972.]

or evacuee. In practice, we believe—and emigrés have indicated—that conditions would be much more congested. Details on equipment and supplies for evacuees (including food, water, medicine, and fuel) are discussed later in this chapter.

134. *Time Requirements for Evacuation.* Soviet sources call for evacuation of Soviet cities within the "special period" (a period of warning) preceding an attack, and imply that the evacuation time would be about 72 hours. Soviet authorities have not published their assessment of actual time which would be required for evacuation of the nonessential population. Several US studies have addressed the speed with which the Soviets could complete their evacuation actions. A 1969 RAND study estimated that 100 million urban residents [27] could be evacuated in four days under optimum conditions, using only half of the available 1970 transportation capacity. A 1976 Defense Intelligence Agency study of the evacuation of 12 selected Soviet cities concluded that, under the most favorable conditions, the Soviets have a physical capability to evacuate most of the 12 cities within three to four days after movement begins. The major assumptions used in the DIA study were:

- 70 percent of population evacuated, 30 percent dispersed;
- two shifts working in essential industries and services;
- a six-hour alert preceding actual movements (this period of alert has been tested in Soviet exercises); and
- no other complications, such as panic, severe disruption of transport systems, or adverse weather conditions.

Figures 18, 19, and 20 and Table V summarize the findings of the DIA dispersal and evacuation study.

[27] This number of urban inhabitants equals the total population of some 450 cities with populations of 50,000 or more and includes almost all major administrative, residential, communication, and transportation centers.

TABLE V

DIA-Estimated Time Required for Evacuation of Twelve Selected Soviet Cities

City	Numbers evacuated (thousands) [1]	Maximum distance (km)	(nm)	Estimated time required after movement begins (hours) [2]	Modes of transport
Leningrad	2,673	[3]		117+	mostly rail, some maritime
Kiev	1,407	110	60	36	rail and highway
Tashkent	1,158	260	140	81	rail
Gor'kiy	914	315	170	75	rail and highway
Odessa	718	[4]		58	mostly rail, some maritime
Dnepropetrovsk	684	185	100	57	rail
Khabarovsk	351	410 [5]	220 [5]	56	rail
Orenburg	288	185	100	47	rail
Kishinev	331	75	40	39	rail and highway
Sevastopol'	187	165	90	29	highway
Angarsk	164	410 [5]	220 [5]	42	rail
Kirovabad	141	95	50	25	rail

[1] Represents 70 percent of city's inhabitants.

[2] Movement begins six hours after the alert. Methodology utilized in calculating evacuation times considers variables such as running speeds, loading and unloading rates, and sequences of unloading dictated by availability of facilities. Since these variables are not known quantities but judgments based on available evidence, the resulting figures for total evacuation time are approximate rather than exact values.

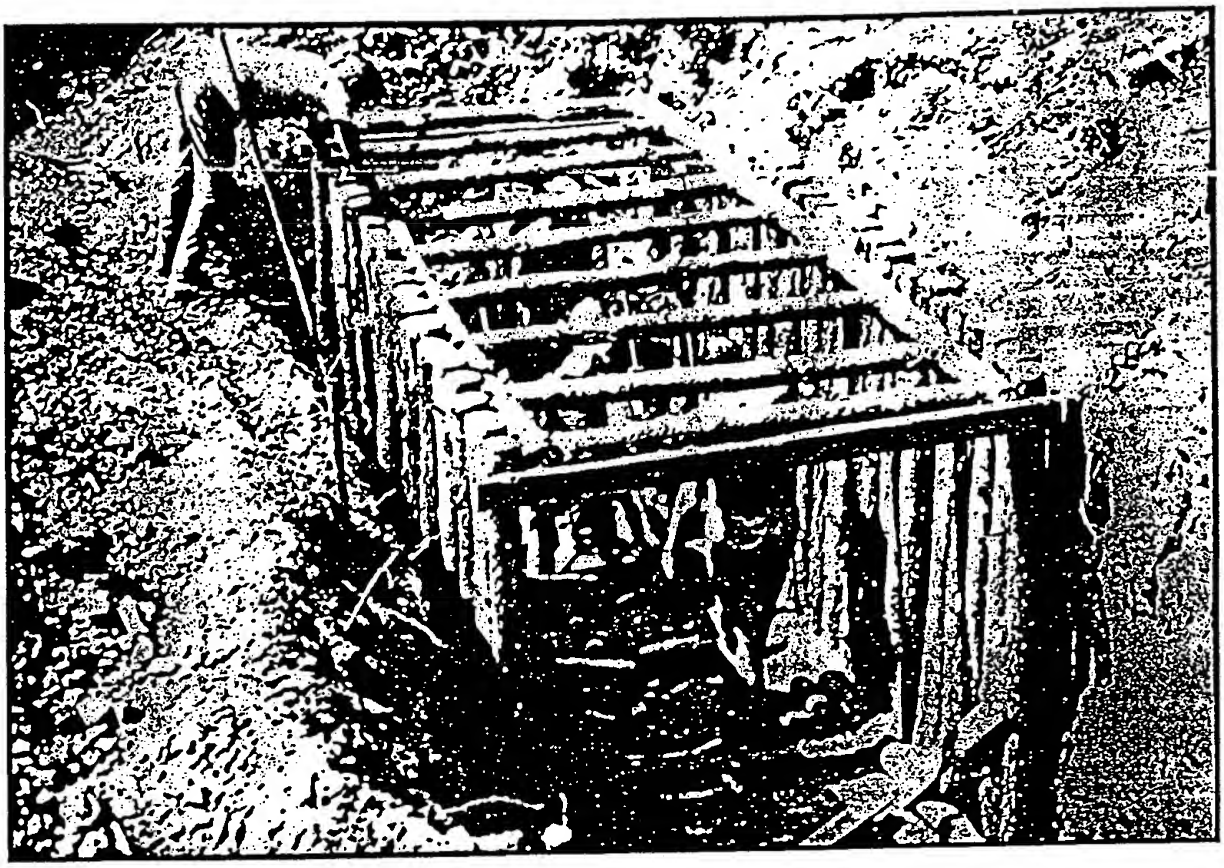
[3] Leningrad can accommodate some 90 large oceangoing ships which could offload evacuees at various ports along the Baltic coast, but a cycle time of three to four days is estimated before ships can return for more evacuees.

[4] Odessa, which can handle some 38 oceangoing ships, could offload evacuees in Romania and Bulgaria, but the cycle time for return of ships is four or more days.

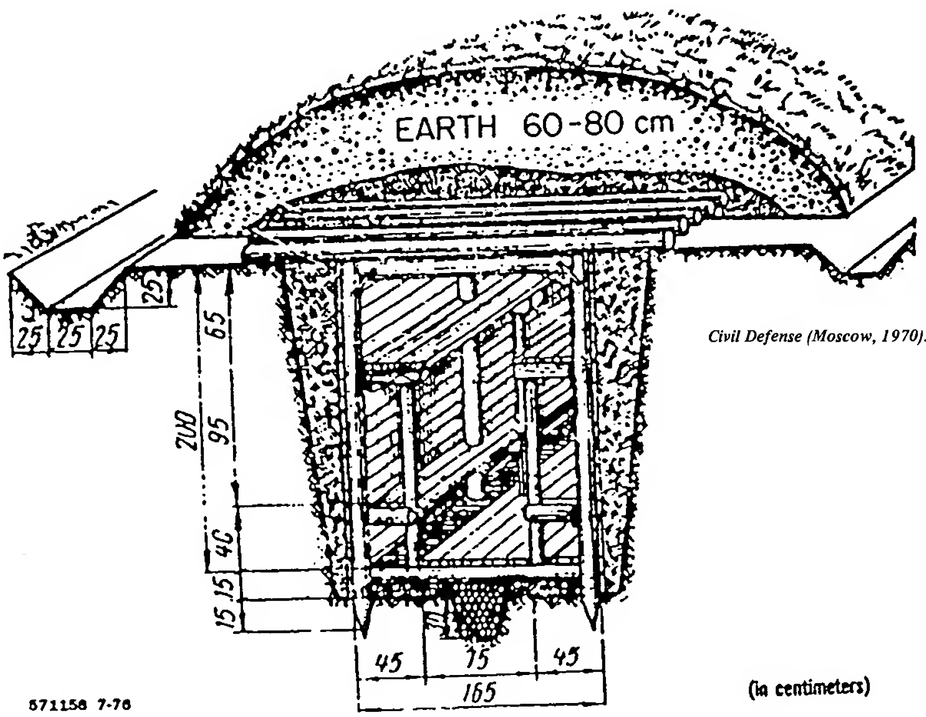
[5] Distances for Khabarovsk and Angarsk are greater than for larger cities because of low population density in surrounding areas.

Figure 21. US Testing of Soviet-Designed Shelter

Sponsored by the Oak Ridge National Laboratory, untrained US citizens constructed and lived in Soviet-designed hasty shelters such as that in the photograph. Normally, as part of the testing, a family averaging six persons built and occupied a shelter within 36 hours to receive a cash bonus. They followed plans from a Soviet civil defense handbook, such as the sketch shown.



[This survived a simulated 1 megaton blast 1 mile away]

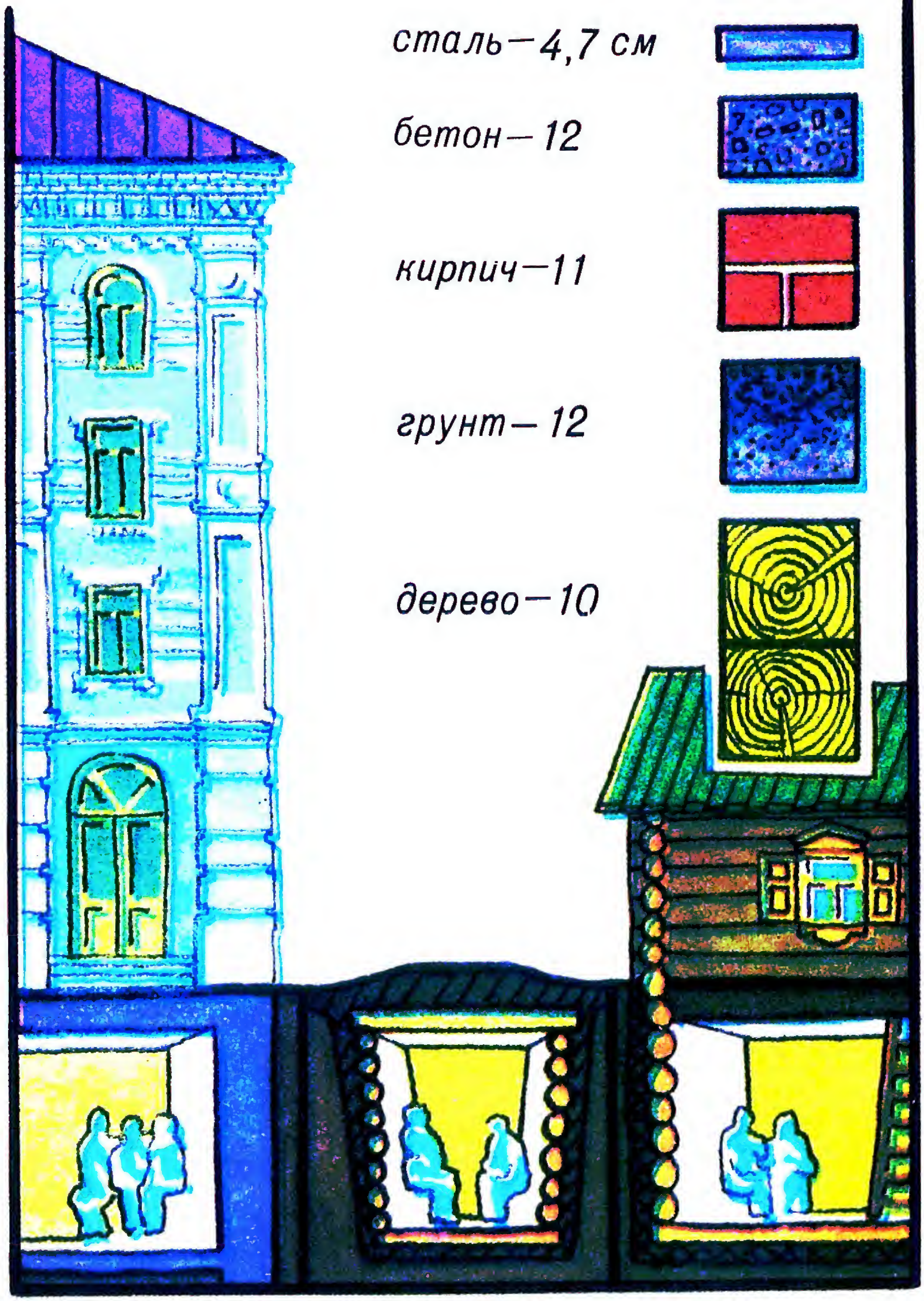


Civil Defense (Moscow, 1970).

(In centimeters)

571158 7-76

Экспозиционную дозу радиации ослабляют вдвое материалы толщиной



ORNL-5037

Nuclear War Survival Skills

Cresson H. Kearny

[Note: Kearny was inspired to write this by the USSR manuals like "Antiradiation shelters in Urban Areas", 1972, English translation: Oak Ridge Nat. Lab., ORNL-TR-2745.]

Oak Ridge National Laboratory
Oak Ridge, Tennessee

September 1979

Summary

Underlying the advocacy of Americans' learning these down-to-earth survival skills is the belief that if one prepares for the worst, the worst is less likely to happen. Effective American civil defense preparations would reduce the probability of nuclear blackmail and war. Yet in our world of increasing dangers, it is significant that the United States spends much less per capita on civil defense than many other countries. The United States' annual funding is about 50 cents per capita, whereas Switzerland spends almost $11 and, most importantly, the Soviet Union spends approximately $20.

In the first chapter the myths and facts about the consequences of a massive nuclear attack are discussed. As devastating as such an attack would be, with adequate civil defense preparations and timely warning much of the population could survive.

One appendix of the handbook gives detailed, field-tested instructions for building six types of earth-covered expedient fallout shelters, with criteria to guide the choice of which shelter to build. The design features of several types of expedient blast shelters are described in another appendix. Two others contain instructions for making an efficient shelter-ventilating pump and a homemade fallout meter that is accurate and dependable. Both of these essentials can be made with inexpensive materials found in most households. Drawings are used extensively, as are photographs of people actually building and living in the various shelters.

This first-of-its-kind report is primarily a compilation and summary of civil defense measures and inventions developed at ORNL over the past 14 years and field-tested in six states, from Florida to Utah.

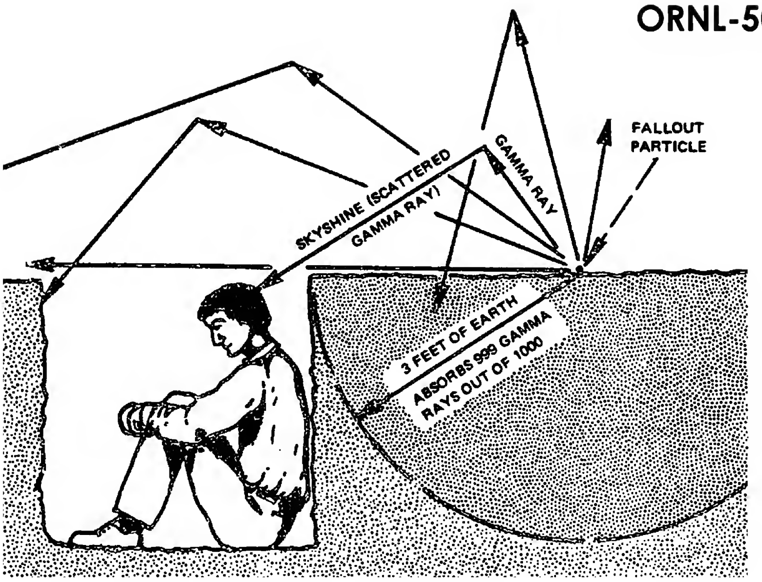
- **Myth:** Fallout radiation from a nuclear war would poison the air and all parts of the environment. It would kill everyone. (This is the demoralizing message of *On the Beach* and many similar pseudo-scientific books and articles.)
- **Myth:** A heavy nuclear attack would set practically everything on fire, causing "firestorms"
- **Myth:** In the worst-hit parts of Hiroshima and Nagasaki where all buildings were demolished, everyone was killed by blast, radiation, or fire.
- **Myth:** Because some modern H-bombs are over 1000 times as powerful as the A-bomb that destroyed most of Hiroshima, these H-bombs are 1000 times as deadly and destructive.

These exaggerations have become demoralizing myths, believed by millions of Americans.

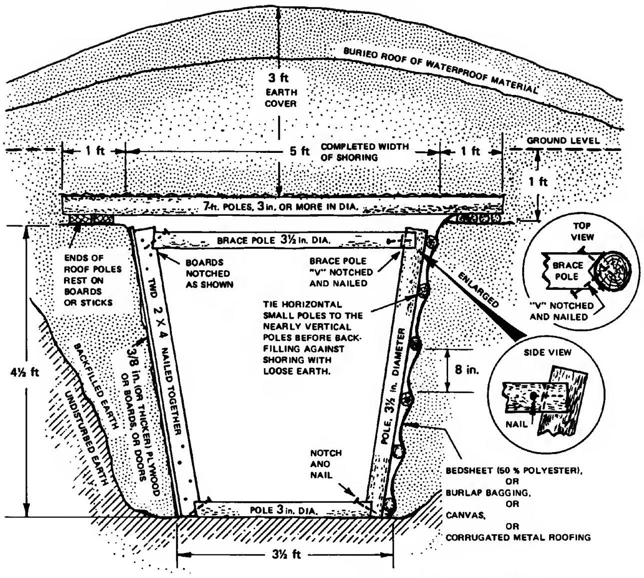
HIROSHIMA. Typical, part below ground, earth-covered, timber framed shelter 300 yds. from the centre of damage

NAGASAKI. Typical small earth-covered back yard shelter with crude wooden frame, less than 100 yds. from the centre of damage

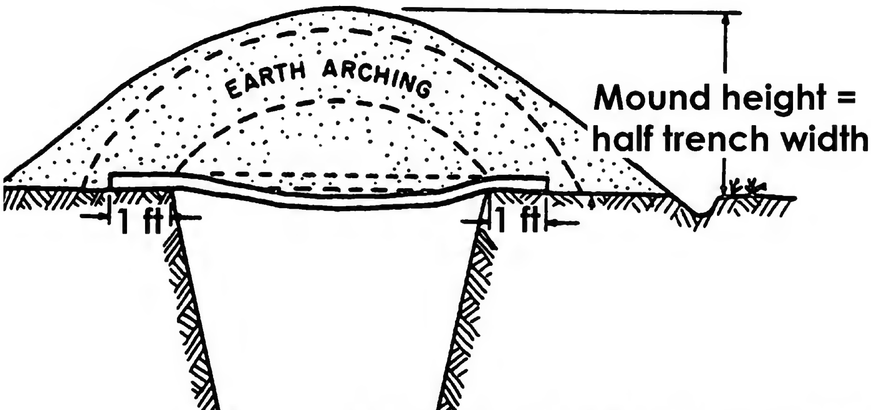
ORNL-5037



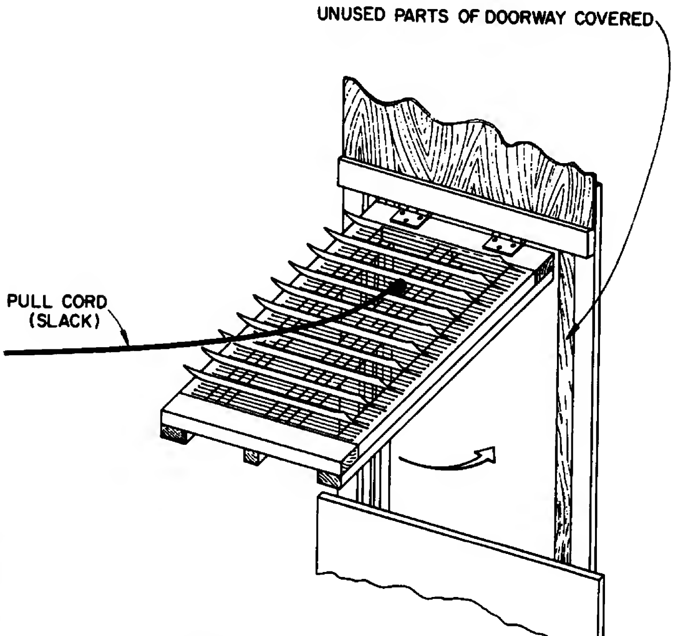
Methods for shoring a trench shelter.



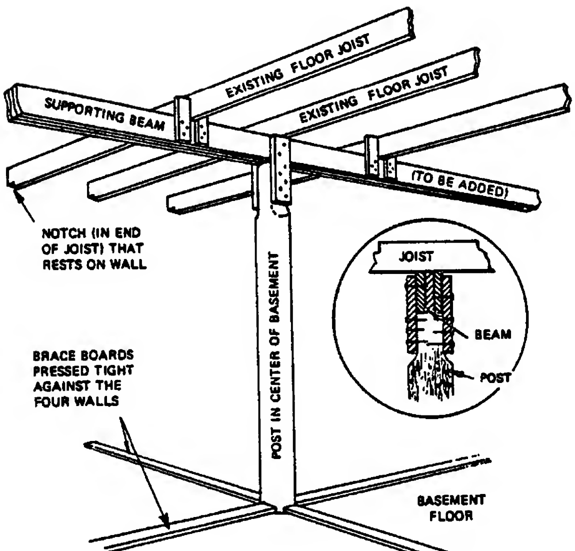
EARTH ARCHING USED TO STRENGTHEN SHELTERS

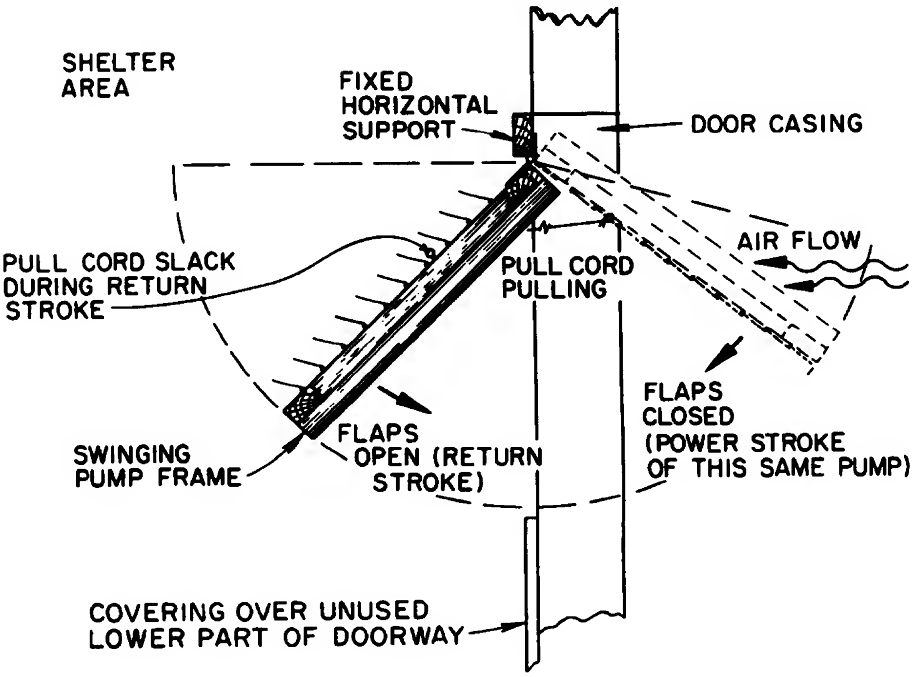


A familiar example of effective earth arching is its use with sheet metal culverts under roads. The arching in a few feet of earth over a thin-walled culvert prevents it from being crushed by the weight of heavy vehicles.

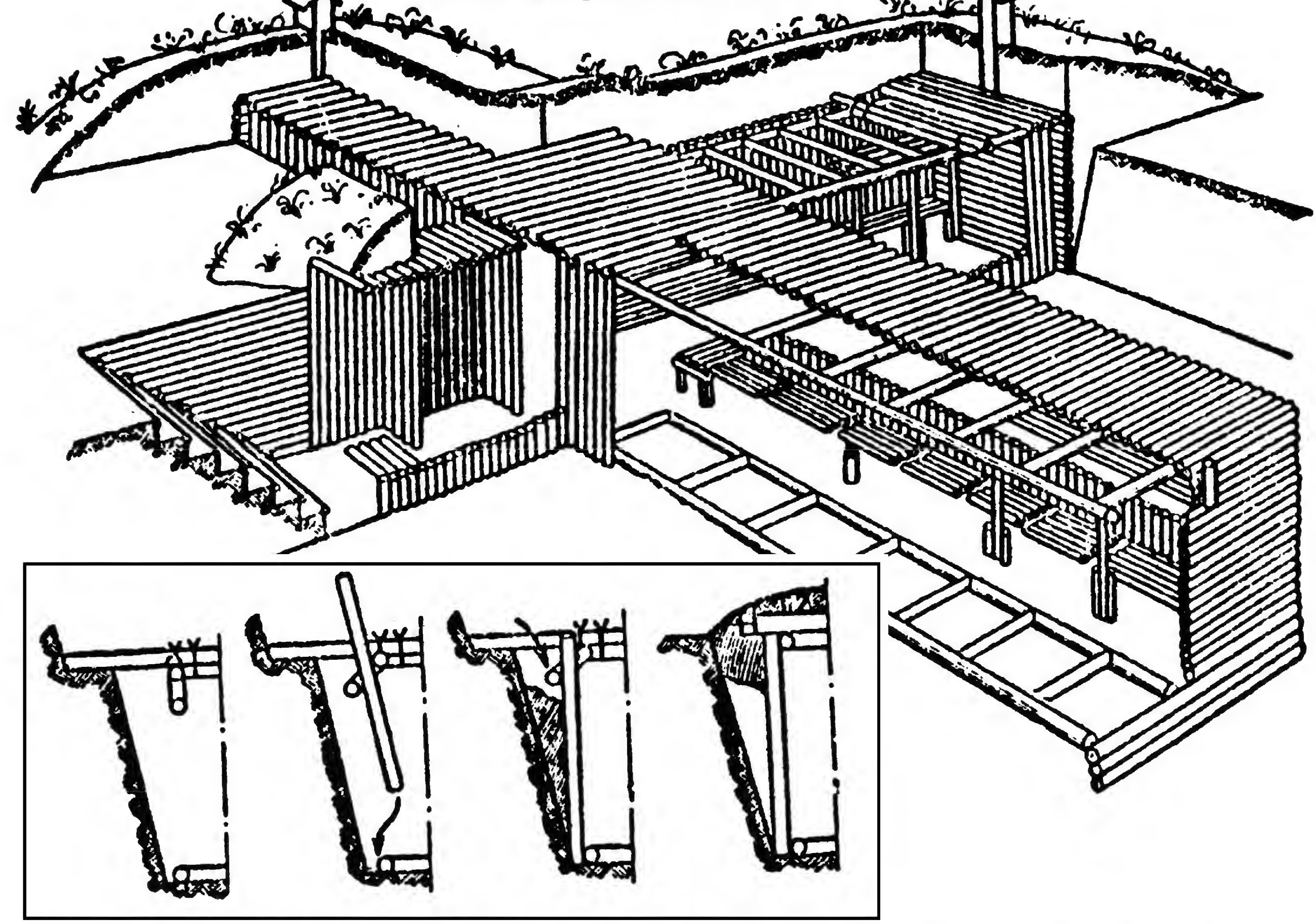


Kearny air pump.

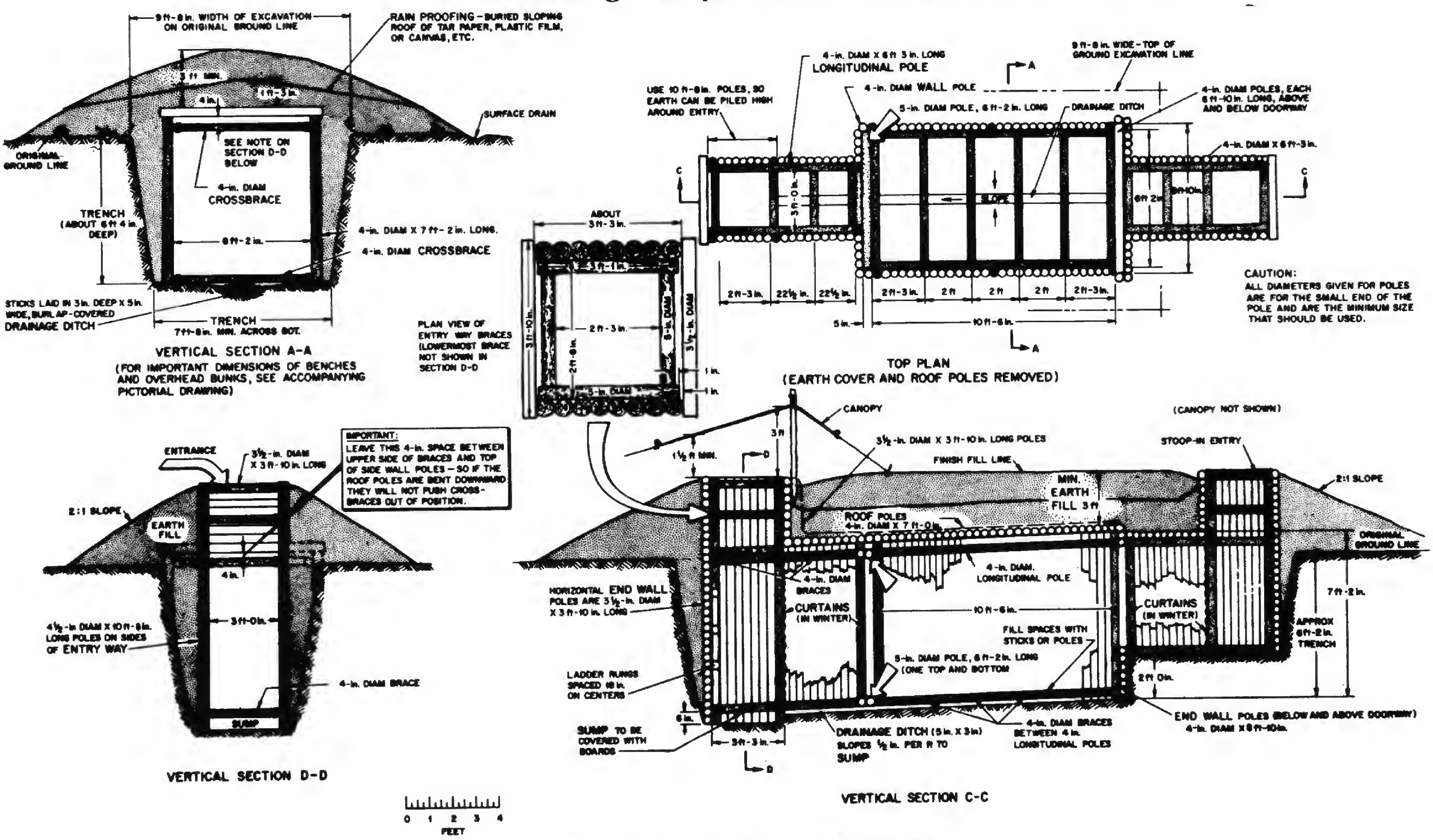




Soviet design for pole shelter.



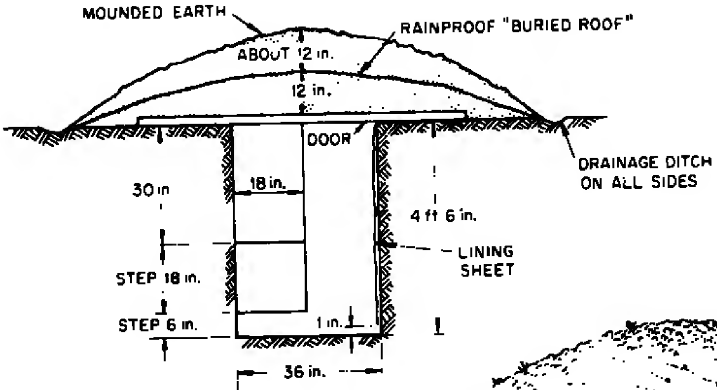
Soviet design for pole shelter adapted for American use

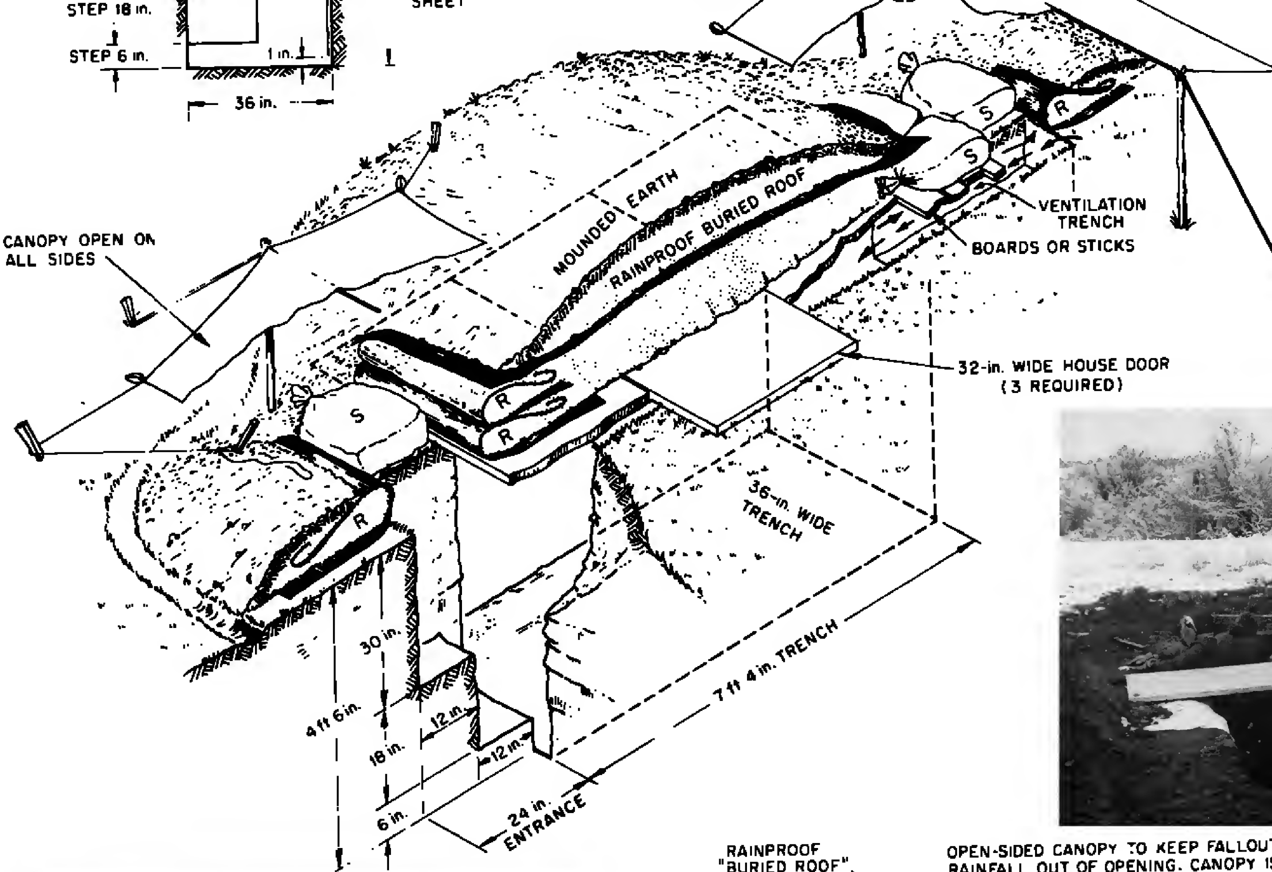


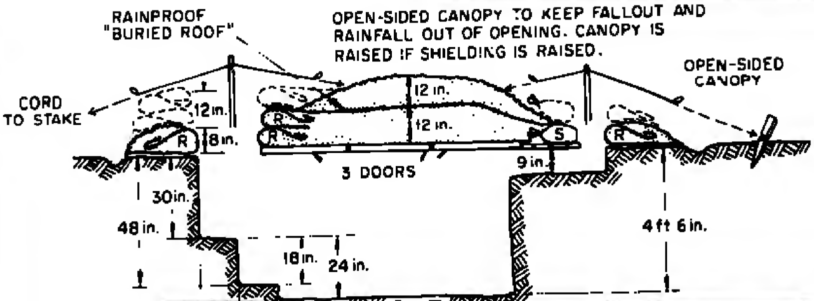
PLAN AND ELEVATION OF SMALL-POLE SHELTER.

ORNL-4979

Door-over-trench shelter.







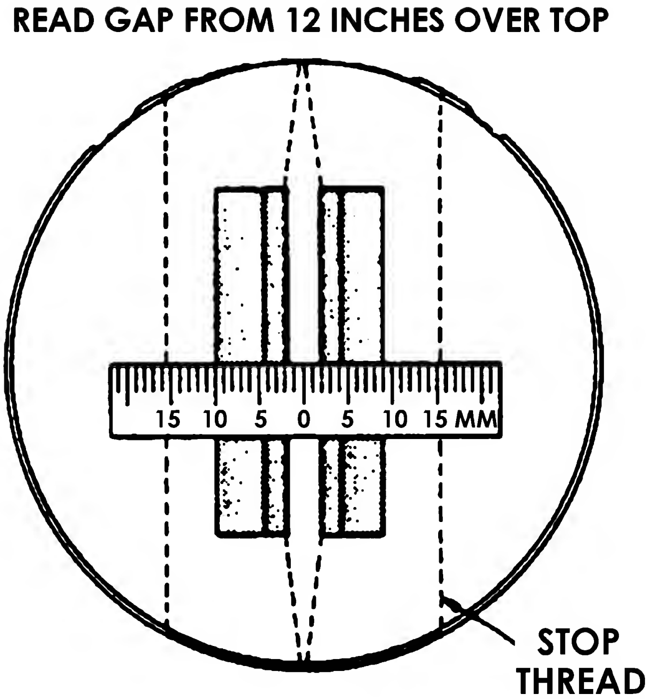
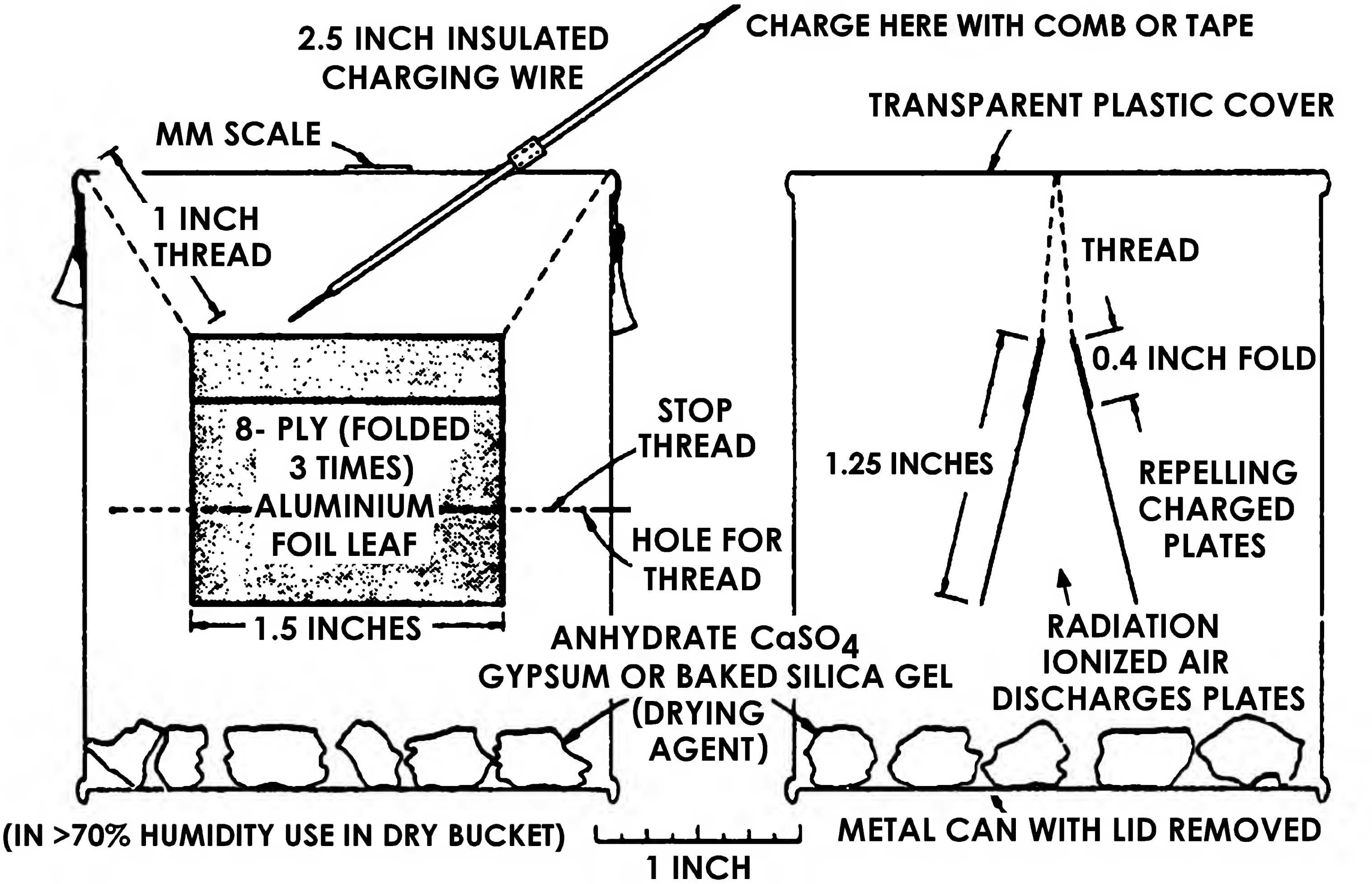


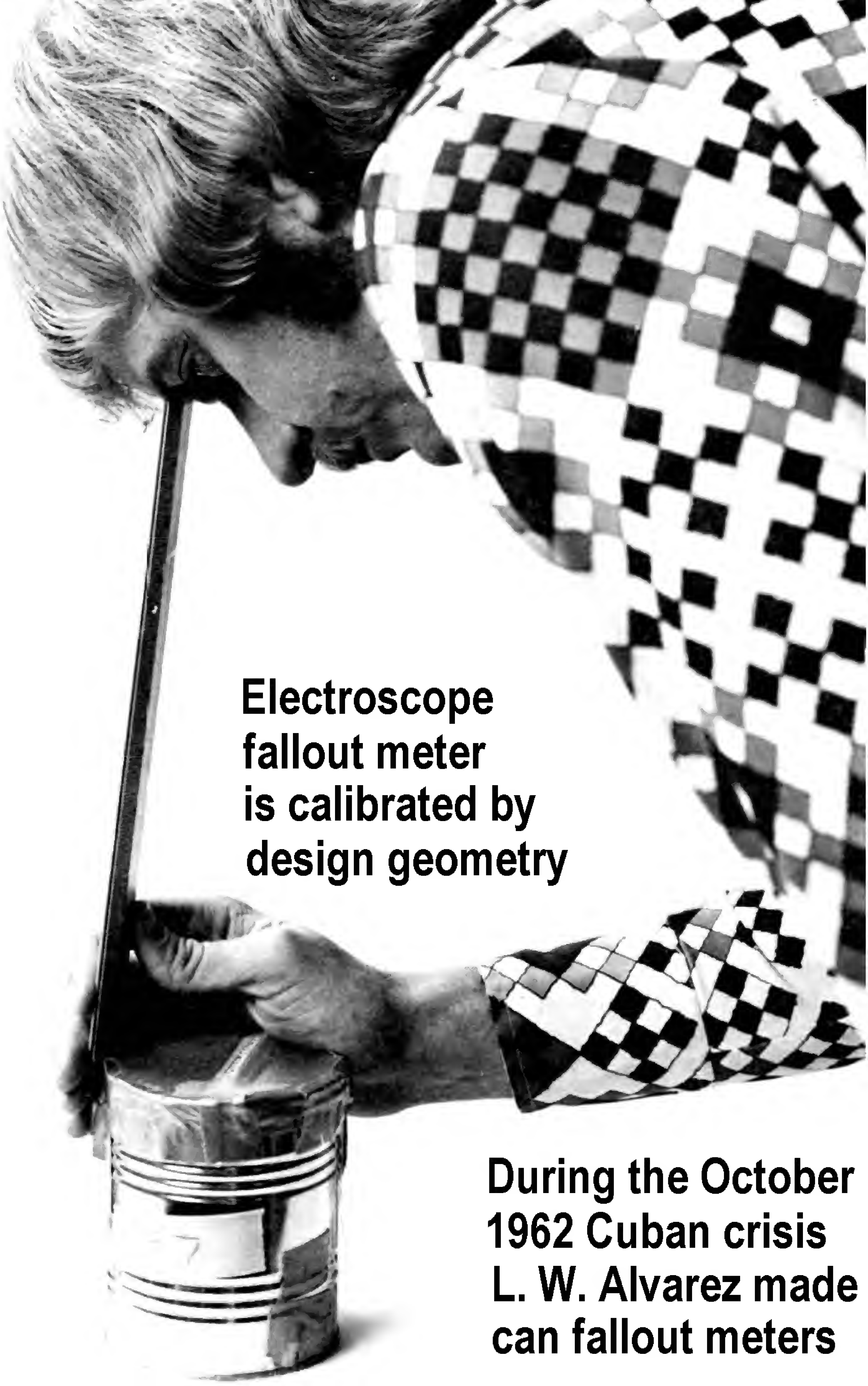
TABLE USED TO FIND DOSE RATES (R/HR)

Reading in mm is difference in gap between aluminium leaves, before and after exposure

	TIME INTERVAL OF RADIATION EXPOSURE				
	15 SEC	1 MIN	4 MIN	16 MIN	1 HR
Reading	R/HR	R/HR	R/HR	R/HR	R/HR
2 MM	6.2	1.6	0.4	0.1	0.03
4 MM	12	3.1	0.8	0.2	0.06
6 MM	19	4.6	1.2	0.3	0.08
8 MM	25	6.2	1.6	0.4	0.10
10 MM	31	7.7	2.0	0.5	0.13
12 MM	37	9.2	2.3	0.6	0.15
14 MM	43	11	2.7	0.7	0.18

Thread for suspending aluminium foil plates must be an insulator (not conductor). Most thread is anti-static (conducting) and no use. Clean human hair, dental floss, or fishing line can be used. Alternatively, thin (about 3 mm wide) strips of flexible plastic from plastic bags can be used.




Electroscope fallout meter is calibrated by design geometry
During the October 1962 Cuban crisis L. W. Alvarez made can fallout meters

PREVENTION OF THYROID DAMAGE FROM RADIOACTIVE IODINES

An extremely small and inexpensive daily dose of the preferred non-radioactive potassium salt, potassium iodide (KI), if taken 1/2 hour to 1 day before exposure to radioactive iodine, will reduce later absorption of radioactive iodine by the thyroid to only about 1% of what the absorption would be without this preventive measure. Extensive experimentation and study have led to the Federal Drug Administration's approval of 130-milligram (130-mg) tablets for this preventive (prophylactic) use only. A 130-mg dose provides the same daily amount of iodine as does each tablet that English authorities for years have placed in the hands of the police near nuclear power plants, for distribution to the surrounding population in the very unlikely event of a major nuclear accident. It is quite likely that a similar-sized dose is in the Russian "individual, standard first-aid packet." According to a comprehensive Soviet 1969 civil defense handbook, this first-aid packet contains "anti-radiation tablets and anti-vomiting tablets (potassium iodide and etaperain)."

FM 101-31-3

DEPARTMENT OF THE ARMY FIELD MANUAL

STAFF OFFICERS FIELD MANUAL

NUCLEAR WEAPONS EMPLOYMENT

HEADQUARTERS, DEPARTMENT OF THE ARMY
FEBRUARY 1963

ATOMIC DEMOLITION MUNITIONS

on the surface

SEVERE DAMAGE RADII—METERS

Materiel classification	*Yield—KT*					
	ALFA/ .5	*BRAVO/ 1*	*DELTA/ 5*	*ECHO/ 10*	*GOLF/ 50*	*HOTEL/ 100*
Tunnels and mines Heavy masonry or concrete dams and bridges	50	50	125	175	225	300
Tanks and artillery Locomotives Supply depots Engineer earthmoving equip Field fortifications	75	100	175	250	450	600
Engineer truck-mounted equip Earth-covered surface shelters Blast-resistant reinforced concrete bldgs	100	100	200	250	400	525
Military vehicles Railroad cars Communications equip Truss and floating bridges Monumental-type multistory wall-bearing bldgs Heavy steel frame industrial bldgs Multistory, reinforced concrete frame bldgs	150	200	375	500	950	1,250
Oil storage tanks Multistory, reinforced concrete bldgs (small window area) Multistory, steel frame office bldgs Light steel frame industrial bldgs	250	300	475	650	1,125	1,425
Multistory, wall-bearing bldgs (apt house type) Parked combat aircraft	375	450	800	1,000	1,700	2,125
Wood frame bldgs	375	650	1,050	1,325	2,275	2,875

Figure 12.1.

CONFIDENTIAL

[redacted]

a/11859

CONFIDENTIAL

Classification (~~Confidential~~) changed to Memo, Ch. Security Div. 8-20-57
By Authority of
By G. Hamos(?) Date OCT 24 1957

HANDBOOK

on

CAPABILITIES

of

ATOMIC WEAPONS

DOWNGRADED AT 12 YEAR
INTERVALS; NOT AUTOMATICALLY
DECLASSIFIED. DOD DIR 5200.10

[redacted]

CONFIDENTIAL

10.3 Damage Criteria

10.32 For those items not included in Table VIII, select the listed item most similar in those characteristics discussed previously as being the important factors in determining the extent of damage to be expected. Perhaps the most important item to be remembered when estimating effects on personnel is the amount of cover actually involved. This cover depends on several items; however, one factor is all important, namely, the degree of forewarning of an impending atomic attack. It is obvious that only a few seconds warning is necessary under most conditions in order to take fairly effective cover. The large number of casualties in Japan resulted for the most part from the lack of warning.

TABLE VIII

ITEM	DAMAGE	AIR SHOCK PSI	REMARKS
Artillery Field (75mm or greater)	Severe	40	Damage to Gun and Cradle
	Moderate	30	Damage to Recoil and Carriage
	Light	5	Damage to Gun Sights
Artillery Field (Less than 75mm)	Severe	25	Damage to Gun and Cradle
	Moderate	15	Damage to Recoil and Loading Mechanism
	Light	5	Damage to Sights
Reinforced Concrete Bldgs.	Severe	25	Collapse
	Moderate	10	Structural damage
	Light	3	Plaster & window damage
Steel, heavy frame Bldgs.	Severe	18	Mass distortion
	Moderate	12	Structural Damage
	Light	3	Plaster & window damage
Steel, light frame Bldgs.	Severe	10	Mass distortion
	Moderate	5	Structural Damage
	Light	3	Plaster & window damage

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DEPARTMENT OF THE ARMY TECHNICAL MANUAL | TM 23-200
DEPARTMENT OF THE NAVY | OPNAV INSTRUCTION 03400.1B
DEPARTMENT OF THE AIR FORCE | AFL 136-1
MARINE CORPS PUBLICATIONS | NAVMC 1104 REV

CAPABILITIES OF ATOMIC WEAPONS (U)

Prepared by
Armed Forces Special Weapons Project

DEPARTMENTS OF THE ARMY, THE NAVY AND THE AIR FORCE

REVISED EDITION NOVEMBER 1957

~~CONFIDENTIAL~~

Personnel in structures. A major cause of personnel casualties in cities is structural collapse and damage. The number of casualties in a given situation may be reasonably estimated if the structural damage is known. Table 6-1 shows estimates of casualty production in two types of buildings for several damage levels. Data from Section VII may be used to predict the ranges at which specified structural damage occurs. Demolition of a brick house is expected to result in approximately 25 percent mortality, with 20 percent serious injury and 10 percent light injury. On the order of 60 percent of the survivors must be extricated by rescue squads. Without rescue they may become fire or asphyxiation casualties, or in some cases be subjected to lethal doses of residual radiation. Reinforced concrete structures, though much more resistant to blast forces, produce almost 100 percent mortality on collapse. The figures of table 6-1 for brick homes are based on data from British World War II experience. It may be assumed that these predictions are reasonably reliable for those cases where the population is in a general state of expectancy of being subjected to bombing and that most personnel have selected the safest places in the buildings as a result of specific air raid warnings. For cases of no prewarning or preparation, the number of casualties is expected to be considerably higher.

6-2

Glass breakage extends to considerably greater ranges than almost any other structural damage, and may be expected to produce large numbers of casualties at ranges where personnel are relatively safe from other effects, particularly for an unwarned population.

Table 6-1. Estimated Casualty Production in Structures for Various Degrees of Structural Damage

	Killed outright	Serious injury (hospitalization)	Light injury (No hospitalization)
1-2 story brick homes (high explosive data):	*Percent*	*Percent*	*Percent*
Severe damage	25	20	10
Moderate damage	<5	10	5
Light damage	......	<5	<5

Note. These percentages do not include the casualties which may result from fires, asphyxiation, and other causes from failure to extricate trapped personnel. The numbers represent the estimated percentage of casualties expected at the maximum range where the specified structural damage occurs.

Personnel in a prone position are less likely to be struck by flying missiles than those who remain standing.

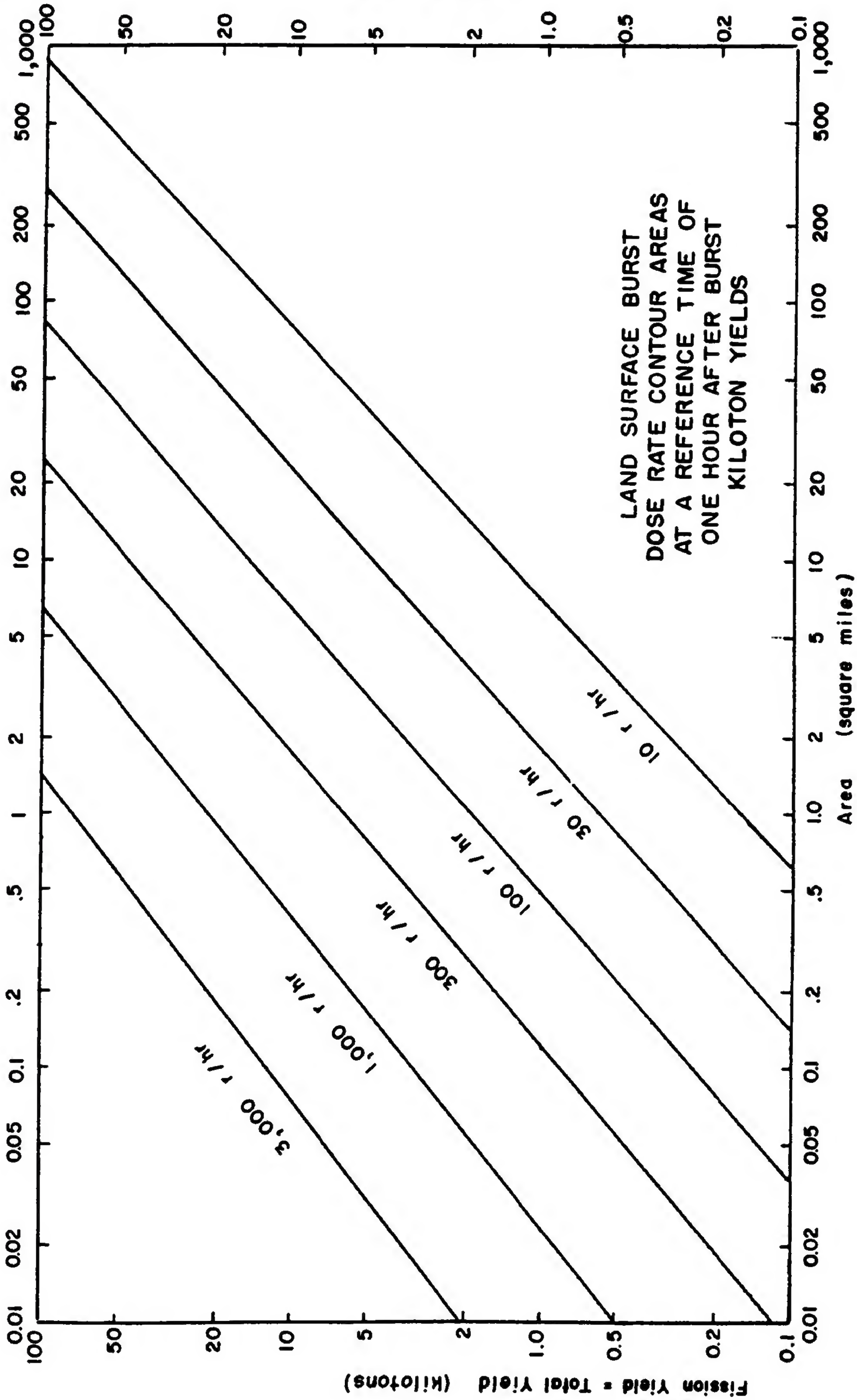
6-3

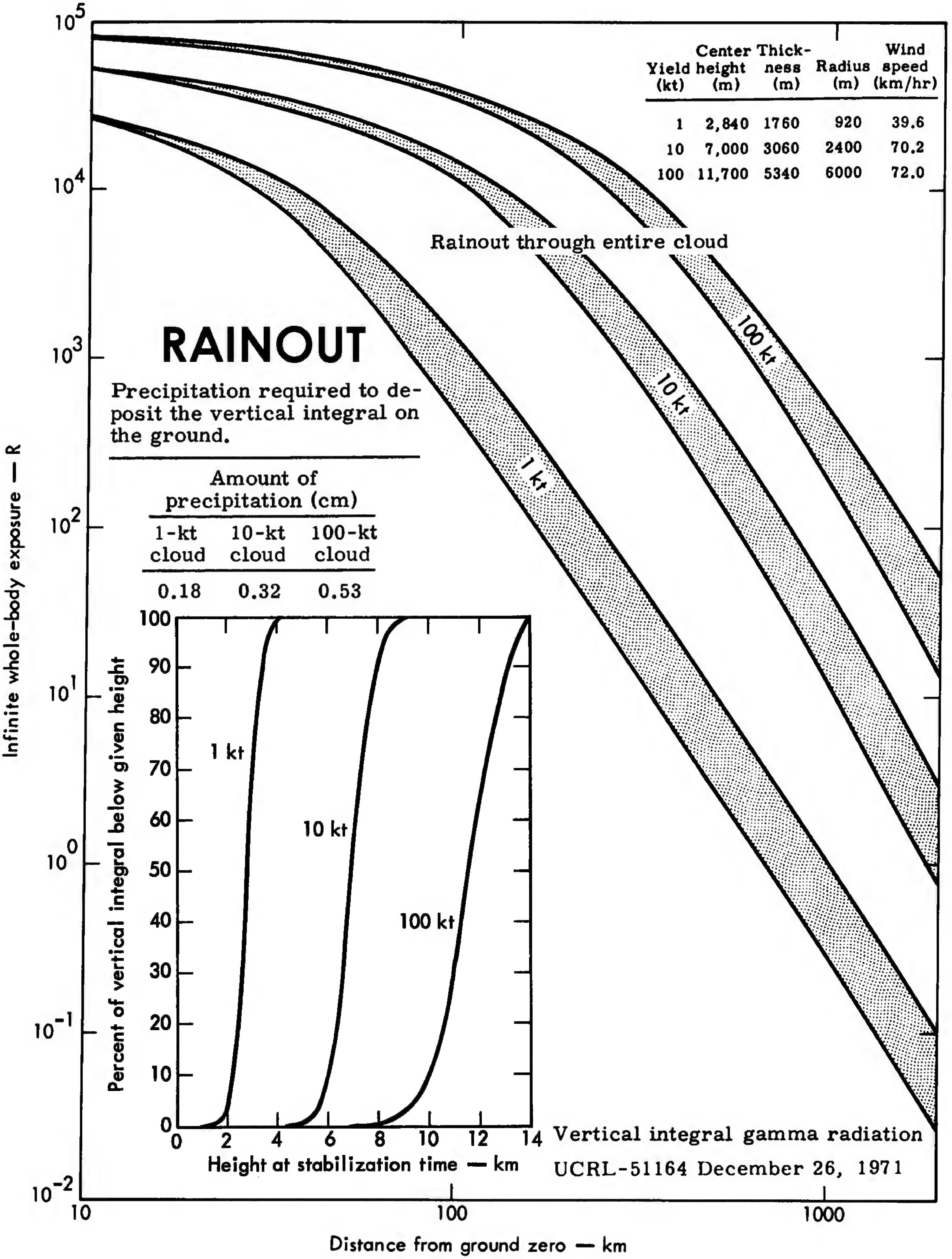
Table 6-2. Critical Radiant Exposures for Burns Under Clothing

(Expressed in cal/cm² incident on outer surface of cloth)

Clothing	Burn	1 KT	100 KT	10 MT
Summer Uniform	1°	8	11	14
(2 layers)	2°	20	25	35
Winter Uniform	1°	60	80	100
(4 layers)	2°	70	90	120

6-4


LAND SURFACE BURST
DOSE RATE CONTOUR AREAS
AT A REFERENCE TIME OF
ONE HOUR AFTER BURST
KILOTON YIELDS
10 r / hr
30 r / hr
100 r / hr
300 r / hr
1,000 r / hr
3,000 r / hr
Area (square miles)
Fission Yield = Total Yield (kilotons)
0.01
0.02
0.05
0.1
.2
.5
1.0
2
5
10
20
50
100
200
500
1,000
0.1
0.2
0.5
1.0
2
5
10
20
50
100



Yield (kt)	Center height (m)	Thickness (m)	Radius (m)	Wind speed (km/hr)
1	2,840	1760	920	39.6
10	7,000	3060	2400	70.2
100	11,700	5340	6000	72.0

Amount of precipitation (cm)		
1-kt cloud	10-kt cloud	100-kt cloud
0.18	0.32	0.53

Vertical integral gamma radiation

UCRL-51164 December 26, 1971

DNA EM-1
PART I

DEFENSE NUCLEAR AGENCY EFFECTS MANUAL NUMBER 1

CAPABILITIES OF NUCLEAR WEAPONS

1 JULY 1972

HEADQUARTERS
Defense Nuclear Agency
Washington, D.C. 20305

FOREWORD

This edition of the *Capabilities of Nuclear Weapons* represents the continuing efforts by the Defense Nuclear Agency to correlate and make available nuclear weapons effects information obtained from nuclear weapons testing, small-scale experiments, laboratory effort and theoretical analysis. This document presents the phenomena and effects of a nuclear detonation and relates weapons effects manifestations in terms of damage to targets of military interest. It provides the source material and references needed for the preparation of operational and employment manuals by the Military Services.

The *Capabilities of Nuclear Weapons* is not intended to be used as an employment or design manual by itself, since more complete descriptions of phenomenological details should be obtained from the noted references. Every effort has been made to include the most current reliable data available on 31 December 1971 in order to assist the Armed Forces in meeting their particular requirements for operational and target analysis purposes.

Comments concerning this manual are invited and should be addressed:

Director
Defense Nuclear Agency
ATTN: STAP
Washington, D. C. 20305

C. H. DUNN
Lt General, USA
Director

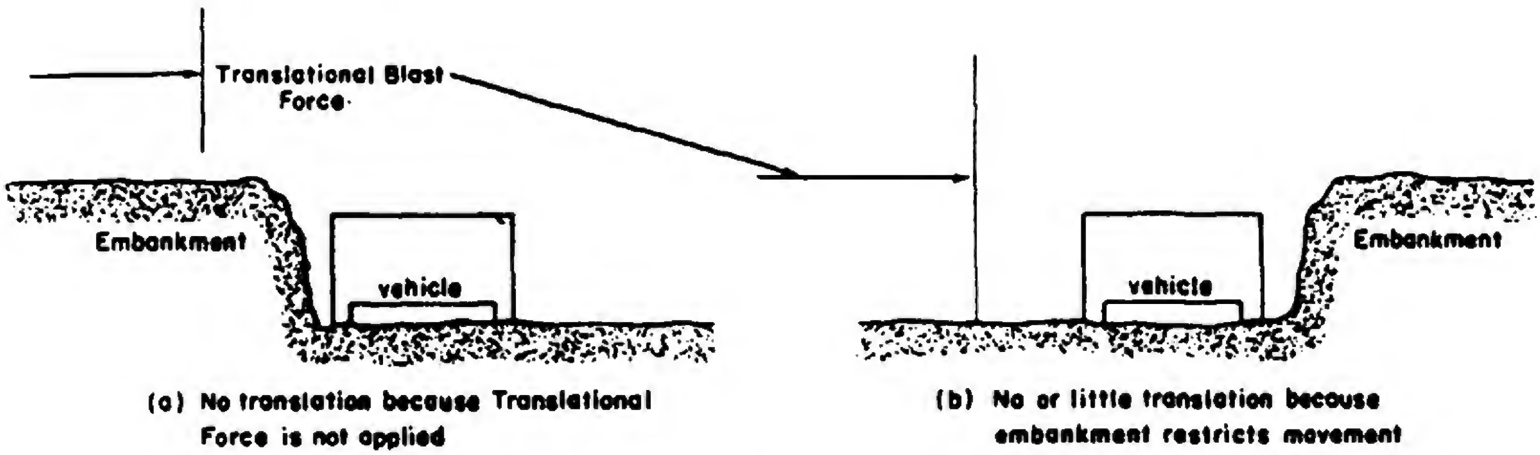


Figure 14-8. The Effect of Shielding

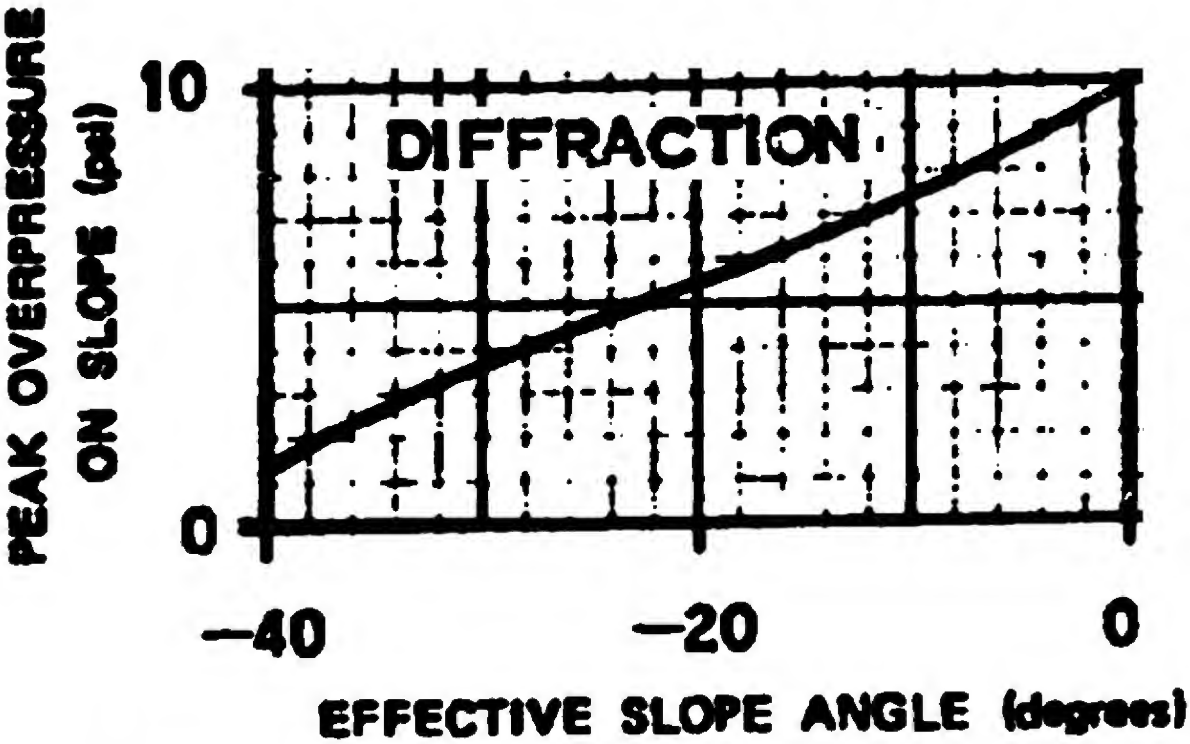


Figure 2-53. Peak Overpressure Produced on a Slope by a 10-psi Incident Mach Stem as a Function of a Slope Angle

Table 10-1 Estimated Casualty Production in Buildings for Three Degrees of Structural Damage

Structural Damage	Percent of Personnel*		
	Killed Outright	Serious Injury (hospitalization)	Light Injury (no hospitalization)
1-2 story brick homes (high-explosive data from England):			
Severe damage	25	20	10
Moderate damage	<5	10	5
Light damage	–	<5	<5
Reinforced-concrete buildings (nuclear data from Japan):			
Severe damage	100	–	–
Moderate damage	10	15	20
Light damage	<5	<5	15

*These percentages do not include the casualties that may result from fires, asphyxiation, and other causes from failure to extricate trapped personnel. The numbers represent the estimated percentages of casualties expected at the maximum range where a specified structural damage occurs. See Chapter 11 for the distances at which these degrees of damage occur for various yields.

Thermal flash on forest leaf canopy produces smoke-screen (in Nevada and Pacific nuclear tests), shadowing dry leaf litter

The high degree of shading by tree crowns and stems for detonations at or below the canopy level often may be offset by scattering of burning debris ignited within the fireball. **15-59**

Fuels seldom burn vigorously, regardless of wind conditions, when fuel moisture content exceeds about 16 percent. This corresponds to an equilibrium moisture content for a condition of 80 percent relative humidity. **15-60**

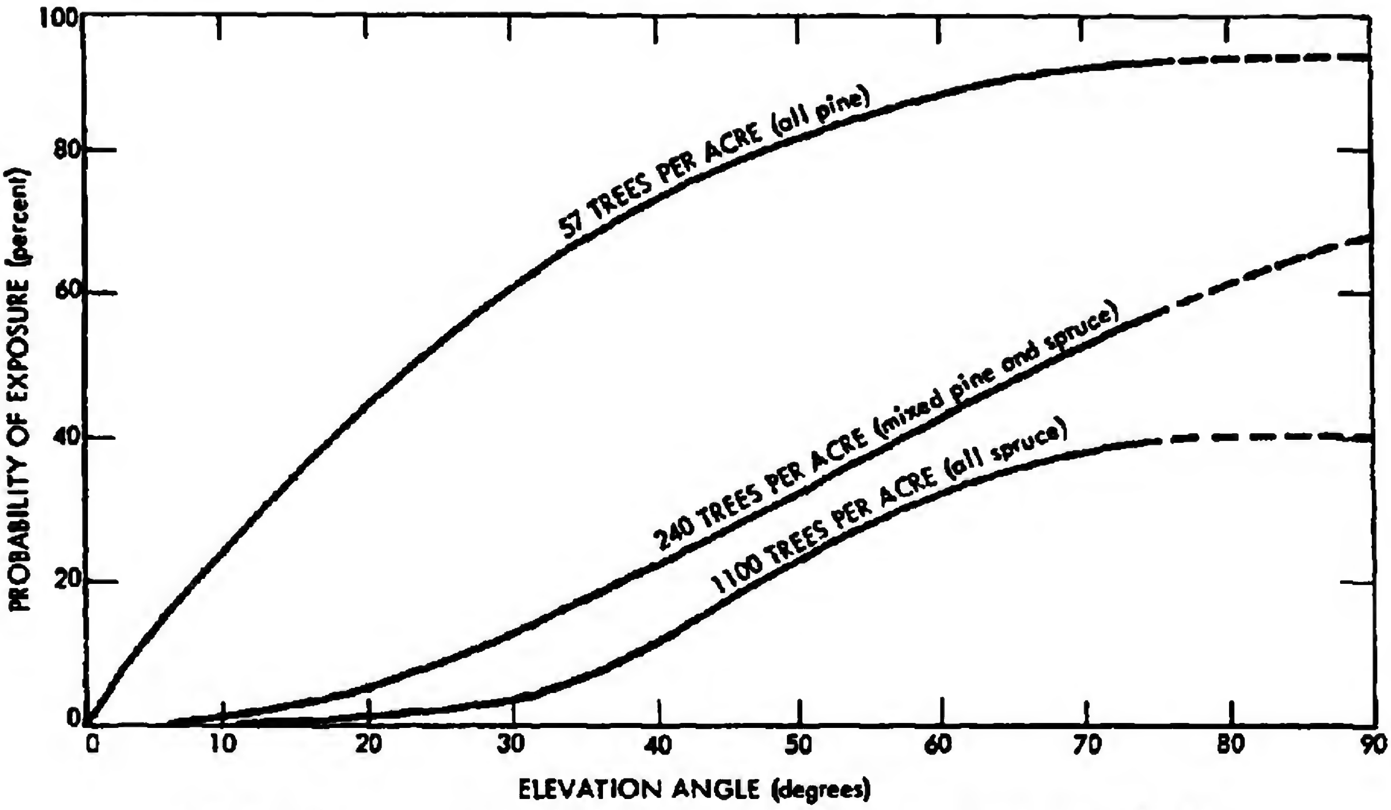


Figure 15-41. Probability of Exposure of Forest Floor for Different Levels of Tree Density

Table 15-13 Burning Durations by Fuel Type

Fuel Type	Violent Burning: Time (min)	Violent Burning: Energy Release (percent)	Residual Burning: Time (min)	Residual Burning: Energy Release (percent)	Total Burning Time
Grass	1.5	90	0.5	10	30 min
Light Brush (12 tons/acre)	2.	60	6.	40	16 hr
Medium Brush (25 tons/acre)	6.	50	24.	50	36 hr
Heavy Brush (40 tons/acre)	10.	40	70.	60	72 hr
Timber	24.	17	157.	83	7 days

Table 15-11 [redacted] Criteria of "No-Spread" of Fires [redacted]

Fuel Type	Criteria
All forest fuels	Over 1 inch of snow on the ground at the nearest weather stations.
Grass	Relative humidity above 80 percent.
Brush or hardwoods	0.1 inch of precipitation or more within the past 7 days and: Wind 0-3 mph; relative humidity 60 percent or higher, or Wind 4-10 mph; relative humidity 75 percent or higher, or Wind 11-25 mph; relative humidity 85 percent or higher.
Conifer timber	1. One day or less since at least 0.25 inch of precipitation and: Wind 0-3 mph; relative humidity 50 percent higher, or Wind 4-10 mph; relative humidity 75 percent higher, or Wind 11-25 mph; relative humidity 85 percent or higher. 2. Two to three days since at least 0.25 inch of precipitation and: Wind 0-3 mph; relative humidity 60 percent or higher, or Wind 4-10 mph; relative humidity 80 percent or higher, or Wind 11-25 mph; relative humidity 90 percent or higher. 3. Four to five days since at least 0.25 inch of precipitation and wind 0-3 mph; relative humidity 80 percent or higher. 4. Six to seven days since at least 0.25 inch of precipitation and wind 0-3 mph; relative humidity 90 percent or higher.

[redacted] shielding from the wind and shading from sunlight by the canopy. The spread or no-spread criteria are summarized in Table 15-11. This table lists the conditions under which fire would not be expected to spread.

[redacted] The criteria of Table 15-11 have been compared to the records of 4,378 wildland fires. Of the fires for which "no spread" would be predicted, 97.8 percent did not spread; only 40 percent of the fires that were predicted to spread actually did spread (at a rate of 0.005 mph or faster). This failure to spread often may be attributable to lack of fuel continuity around the point of origin.

[redacted] The criteria of Table 15-11 are considered to be reliable for American forests and suitably conservative to assure a low level of hazard to friendly forces. On the other hand, the criteria are probably not overly conservative to predict conditions for which enemy forces may be denied forested areas because of fire whenever the local weather history and conditions at the time of

[redacted] SURVIVAL IN FIRE AREAS [redacted]

[redacted] The best documented fire storm in history (but not the one causing the greatest loss of life) occurred in Hamburg, Germany during the night of July 27-28, 1943, as a result of an incendiary raid by Allied forces. Factors that contributed to the fire included the high fuel loading of the area and the large number of buildings ignited within a short period of time.

[redacted] The main raid lasted about 30 minutes. Since the air raid warning and the first high explosive bombs caused most people to seek shelter, few fires were extinguished during the attack. By the time the raid ended, roughly half the buildings in the 5 square-mile fire storm area were burning, many of them intensely. The fire storm developed rapidly and reached its peak in two or three hours.

[redacted] Many people were driven from their shelters and then found that nearly everything was burning. Some people escaped through the streets; others died in the attempt; others returned to their shelters and succumbed to carbon monoxide poisoning.

[redacted] Estimates of the number that were killed range from about 40,000 to 55,000. Most of the deaths resulted from the fire storm. Two equally heavy raids on the same city (one occurred two nights earlier; the other, one night later) did not produce fire storms, and they resulted in death rates that have been estimated to be nearly an order of magnitude lower.

[redacted] More surprising than the number killed is the number of survivors. The population of the fire storm area was roughly 280,000. Estimates have been made that about 45,000 were rescued, 53,000 survived in non-basement shelters, and 140,000 either survived in basement shelters or escaped by their own initiative.

9-25 Causes of Death [redacted]

[redacted] The evidence that can be reconstructed from such catastrophes as the Hamburg fire storm indicates that carbon monoxide and excessive heat are the most frequent causes of death in mass fires. Since the conditions that offer protection from these two hazards generally provide protection from other hazards as well, the following discussion is limited to these two causes of death.

[redacted] *Carbon Monoxide.* Burning consists of a series of physical and chemical reactions. For most common fuels, one of the last of the reactions is the burning of carbon monoxide to form carbon dioxide near the tips of the flames. If the supply of air is limited, as it is likely to be if the fire is in a closed room or at the bottom of a pile of debris from a collapsed building, the carbon monoxide will not burn completely. Fumes from the fire will contain a large amount of this tasteless, odorless, toxic gas.

[redacted] During the Hamburg fire, many basement shelters were exposed to fumes. Imperfectly fitting doors and cracks produced by exploding bombs allowed carbon monoxide to penetrate these shelters. The natural positions of many of the bodies recovered after the raid indicated that death had often come without warning, as is frequently the case for carbon monoxide poisoning.

[redacted] Carbon monoxide kills by forming a more stable compound with hemoglobin than either oxygen or carbon dioxide will form. These latter are the two substances that hemoglobin ordinarily carries through the blood stream. Carbon monoxide that is absorbed by the blood reduces the oxygen carrying capacity of the blood, and the victim dies from oxygen deficiency.

[redacted] As a result of the manner that carbon monoxide acts, it can contribute to the death of a person who leaves a contaminated shelter to attempt escape through the streets of a burning city. A person recovering from a moderate case of carbon monoxide poisoning may feel well while he is resting, but his blood may be unable

[redacted]

to supply the oxygen his body needs when he exerts himself. After the air raid at Hamburg. victims of carbon monoxide poisoning. apparently in good health. collapsed and died from the strain of walking away from a shelter. It is suspected that many of the people who died in the streets of Hamburg were suffering from incipient carbon monoxide poisoning.

[redacted] *Heat.* The body cools itself by perspiration. When the environment is so hot that this method fails. body temperature rises. Shortly thereafter, the rate of perspiration decreases rapidly. and. unless the victim finds immediate relief from the heat, he dies of heat exhaustion. Death from excessive heat may occur in an inadequately insulated shelter: it also may occur in the streets if a safe area cannot be located in a short time.

9-26 Shelters [redacted]

[redacted] The results of the Hamburg fire storm illustrate the value of shelters during an intense mass fire. The public air raid shelters in Hamburg had very heavy walls to resist large bombs. Reinforced concrete three feet thick represented typical walls. Some of these shelters were fitted with gas proof doors to provide protection from poison gas. These two features offered good protection from the heat and toxic gases generated by the fire storm.

[redacted] The public shelters were of three types:

- *Bunkers.* These were large buildings of several shapes and sizes, designed to withstand direct hits by large bombs. The fire storm area included 19 bunkers designed to hold a total of about 15,000 people. Probably twice this number occupied the bunkers during the fire storm, and all of these people survived.
- *Splinterproof Shelters.* These were long single story shelters standing free of other buildings and protected by walls of reinforced concrete at least 2-1/2 feet thick. No deaths resulting from the fire storm were reported among occupants of these shelters. These structures were not gasproof. Distance from burning structures and low height of the shelters probably provided protection from carbon monoxide.
- *Basement Shelters.* The public shelters that were constructed in large basements had ceilings of reinforced concrete 2 to 5 feet thick. Although reports indicate that some of the occupants of these shelters survived and some did not, statistics to indicate the chance of survival in such structures are not available.
- *Private Basement Shelters.* Private basements were constructed solidly, but most of them lacked the insulating value of very thick walls and the protection of gas-tight construction. Emergency exits (usually leading to another shelter in an adjacent building) could be broken if collapse of the building caused the normal exit to be blocked. As a result of the total destruction in the fire storm area, this precaution was of limited value. Many deaths occurred in these shelters as a result of carbon monoxide poisoning, and the condition of the bodies indicated that intolerable heat followed the carbon monoxide frequently. In some cases, the heat preceded the poisonous gas and was the cause of death. Generally, these shelters offered such a small amount of protection that the occupants were forced out within 10 to 30 minutes. Most of these people were able to move through the streets and escape. Others were forced out later when the fire storm was nearer its peak intensity, and few of these escaped. A few people survived in private basement shelters.

2-45 Air Blast from Weapons with Enhanced Radiation Outputs

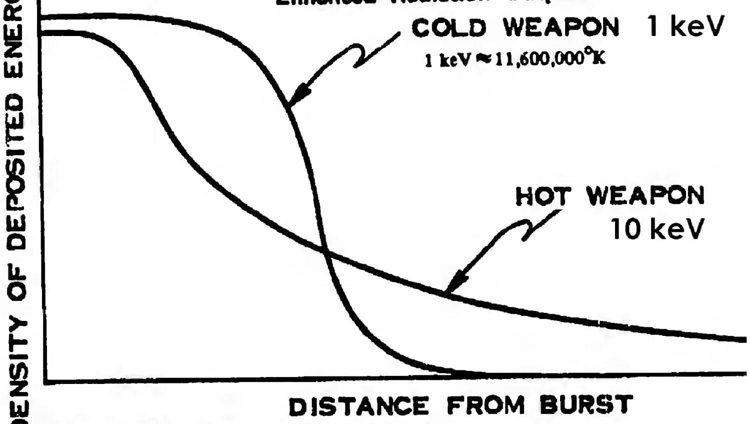


Figure 2-67 Energy Deposition in Air

Rough calculation may be made, ~~however,~~ by applying the following rule of thumb to weapons with enhanced outputs: blast calculations for a given radius may be based on a weapon yield that is equal to the amount of energy contained in the sphere defined by that radius. As this rule implies, the blast wave, as it propagates outward, picks up hydrodynamic energy from the heated air through which it passes. 2-140

THE THERMAL PULSE FROM SPECIAL WEAPONS

As stated in paragraph 2-45, Chapter 2, weapons that have enhanced radiation out- 3-56
puts, i.e., weapons that produce a large fraction of their output in the form of neutrons, gamma rays, or X-rays [redacted] will, in most cases, generate a weaker blast wave than a nominal weapon of the same yield. Similarly, the thermal pulse from such special weapons may be weaker than that from a nominal weapon. The explanation for the reduced thermal output is the same as the explanation for a weaker blast wave: neutrons, gamma rays, and high energy X-rays travel much farther through the atmosphere than the energy from a conventional weapon; therefore, a large portion of the weapon energy may be absorbed by air far from the burst. This air will not become sufficiently hot to contribute effectively to either the blast wave or to the thermal pulse.

[redacted] The terms "nominal weapon" and "conventional weapon" used in the preceding paragraph refer to a nuclear weapon that radiates 70 to 80 percent of its energy as X-rays [redacted] and retains nearly all of the remaining energy as thermal and kinetic energy of the weapon debris (see paragraph 4-4, Chapter 4).

3-17 Effective Thermal Yield of Special Weapons

The modified thermal effects produced by weapons with enhanced outputs may be calculated in terms of an effective thermal yield. This is defined as the yield that a nominal warhead would have in order to radiate the same thermal energy as the special weapon. 3-57

Effective thermal yield is roughly the amount of energy that the nuclear source deposits within a sphere the size of the fireball at the time of the principal minimum. This radius is

$$R_{min} = \frac{29\ W^{0.36}}{(\rho/\rho_o)^{0.22}}\ \text{meters,}$$

where W is the weapon yield in kilotons, ρ is the ambient air density at the burst altitude, and ρ_o is the ambient density at sea level. Energy that is deposited beyond the radius R_{min} is assumed to make a negligible contribution to the energy radiated by the fireball.

Since the size of the fireball is determined by the thermal energy it contains, it would be logical to let W represent effective thermal yield rather than total weapon yield. To do this requires a trial-and-error approach. 3-58

The components of energy deposited within R_{min} of the burst are added together to obtain the effective thermal yield 3-59

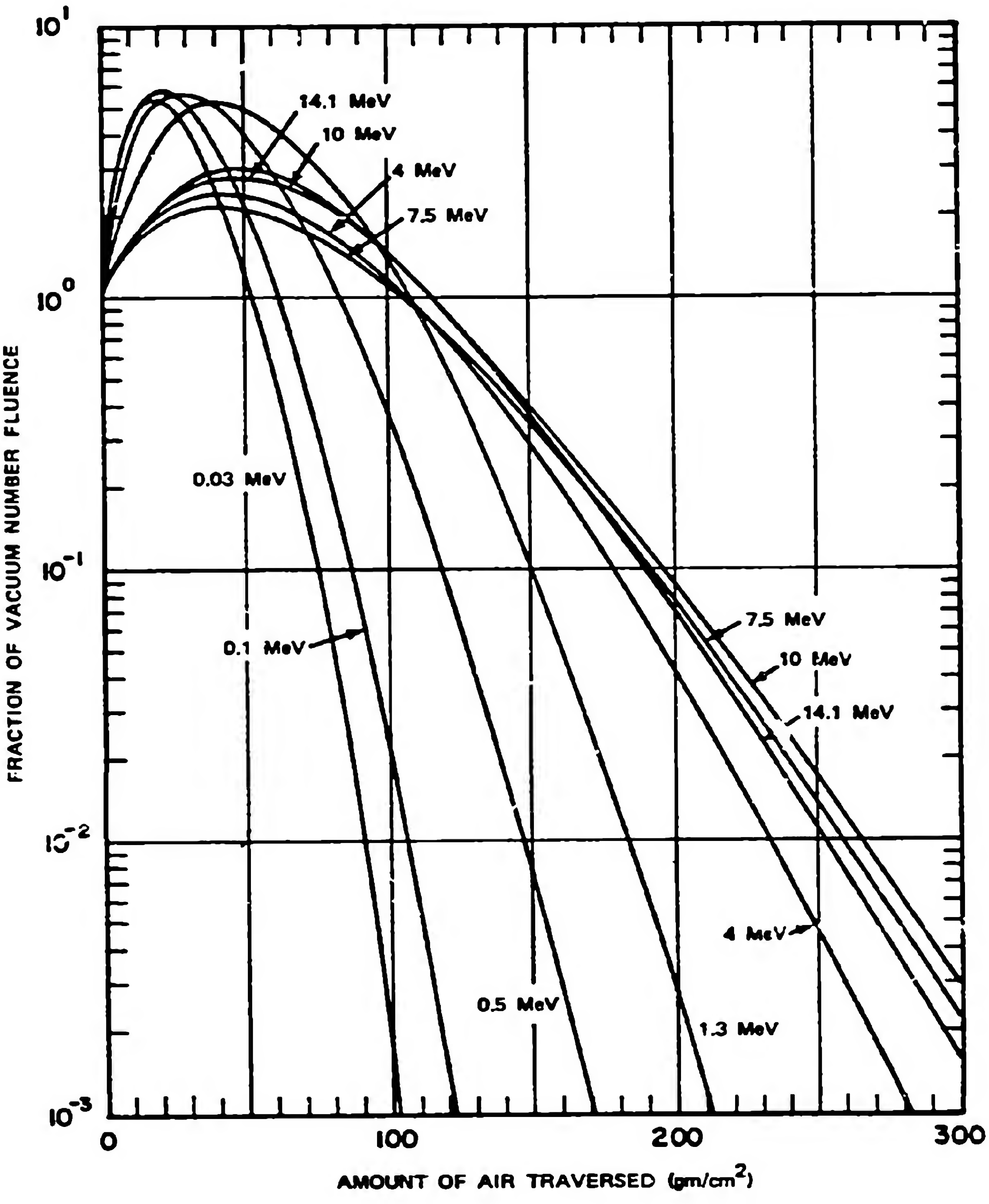


Figure 5-7. Neutron Energy Build-Up Factors for Various Monoenergetic Sources in Homogeneous Air

Chapter 7

ELECTROMAGNETIC PULSE (EMP) PHENOMENA

The nuclear electromagnetic pulse (EMP) is the time-varying electromagnetic radiation resulting from a nuclear burst. It has a very broad frequency spectrum, ranging from near dc to several hundred MHz.

The generation of EMP from a nuclear detonation was predicted even before the initial test, but the extent and potentially serious degree of EMP effects were not realized for many years. Attention slowly began to focus on EMP as a probable cause of malfunction of electronic equipment during the early 1950s. Induced currents and voltages caused unexpected equipment failures during nuclear tests, and subsequent analysis disclosed the role of EMP in such failures. Finally in 1960 the possible vulnerability of hardened weapon systems to EMP was officially recognized. Increased knowledge of the electric and magnetic fields became desirable for both weapons diagnostics and long-range detection of nuclear detonations. For all these reasons a more thorough investigation of EMP was undertaken.

Theoretical and experimental efforts were expanded to study and observe EMP phenomenology and to develop appropriate descriptive models. A limited amount of data had been gathered on the phenomenon and its threat to military systems when all aboveground testing was halted in 1962. From this time reliance has been placed on underground testing, analysis of existing atmospheric test data, and nonnuclear simulation for experimental knowledge. Extended efforts have been made to improve theoretical models and to develop associated computer codes for predictive studies. At the same time, efforts to develop simulators capable of producing threat-level pulses for system coupling and response studies have been expanded.

This chapter describes the EMP generation mechanism and the resulting environment for various burst regimes. The description is largely qualitative, since the complexity of the calculations requires that heavy reliance be placed on computer code calculations for specific problems. Some results of computer code calculations are presented, but generalization of these results is beyond the scope of this chapter. More complete treatments of the EMP phenomena may be found in the "DNA EMP (Electromagnetic Pulse) Handbook (U)" (see bibliography).

ENVIRONMENT – GENERAL DESCRIPTION

7-1 Weapon Gamma Radiation

The gamma radiation output from a nuclear burst initiates the processes that shape the development of an electromagnetic pulse. The gamma radiation components important in EMP generation are the prompt, air inelastic, and isomeric gammas (see Chapter 5). Briefly, the prompt gammas arise from the fission or fusion reactions taking place in the bomb and from the inelastic collisions of neutrons with the weapon materials. The fraction of the total weapon energy that may be contained in the prompt gammas will vary nominally from about 0.1% for high yield weapons to about 0.5% for low yield weapons, depending on weapon design and size. Special designs might increase the gamma fraction, whereas massive, inefficient designs would decrease it.

(a) Blue Gill Taken From Burst Locale

50 km altitude

(b) Teak Taken From Maui (1300 km Away)

77 km altitude

(c) Check Mate Taken From Burst Locale

147 km altitude

The length along the geomagnetic field is about 1,000 kilofeet. The heated air within the fireball is highly ionized, with many striations oriented along the geomagnetic field. (The dark spots within the fireball are rocket trails.)

Figure 1-4. Photographs of High Altitude Bursts, t = 100 sec

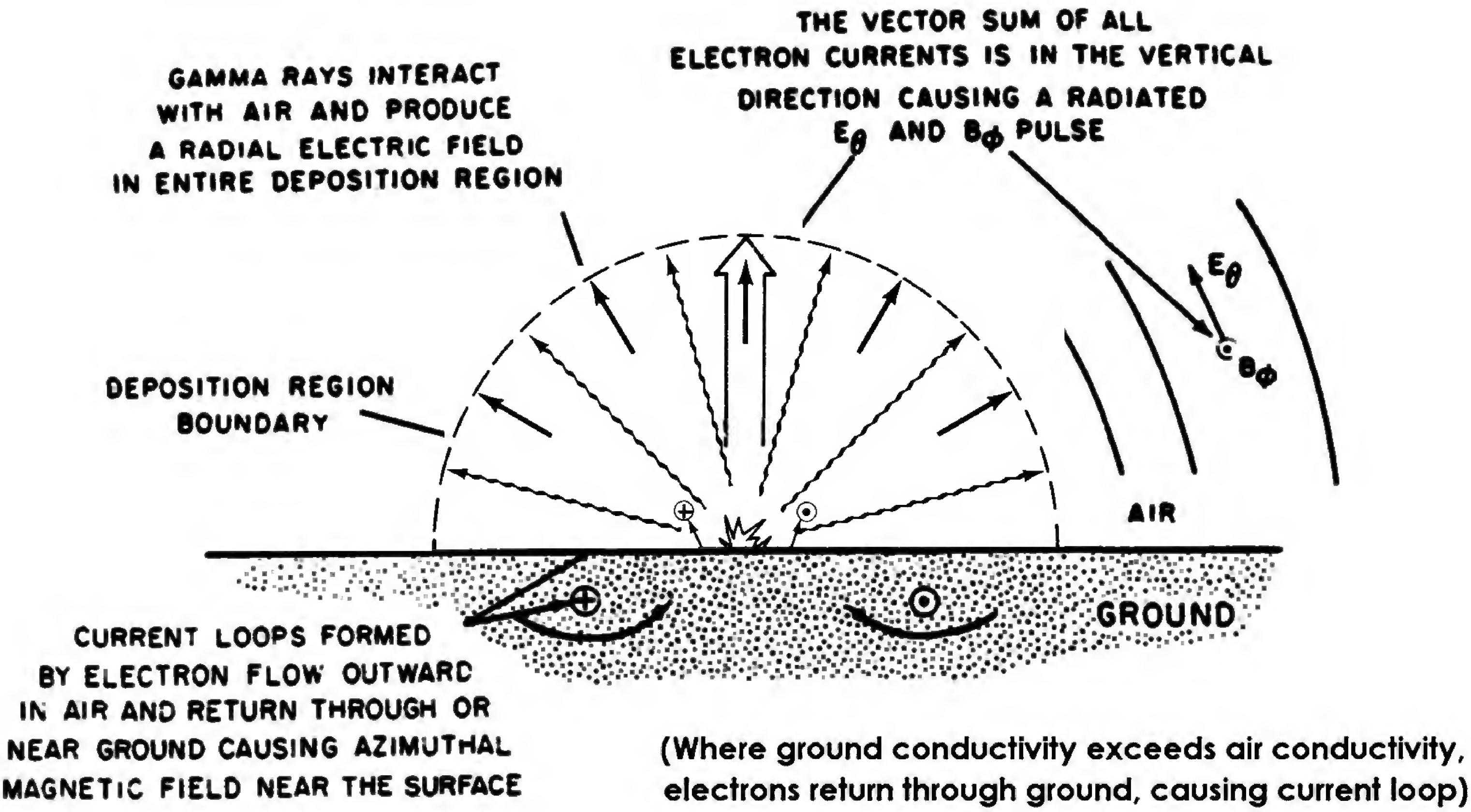


Figure 7-9 Simple Illustration of Surface Burst EMP

The magnitude of the peak value of the radiated electric waveform for a surface burst is a weak function of yield, varying from about 1,300 volts per meter at R_o for a 4.2 TJ (1KT) explosion to about 1,670 volts per meter for a 4.2×10^4 TJ (10 MT) explosion. For most cases, a value of 1,650 volts per meter may be assumed. At ranges along the surface beyond R_o, the peak radiated electric field varies inversely with the distance from the burst. Thus, the magnitude of the peak radiated electric field along the surface may be estimated from the equation

$$E = \frac{R_o}{R} E_o \; ,$$

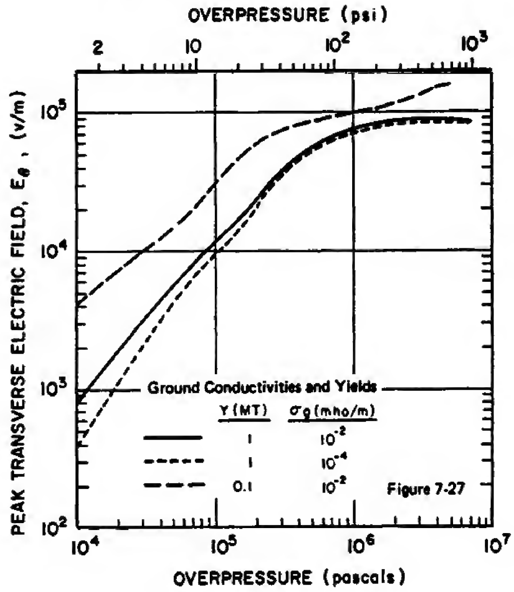
where R_o is the range to the beginning of the radiation region, R is the distance along the surface to the point of interest, E_o is the peak value of the radiated field at R_o (assumed to be about 1,650 volts per meter), and E is peak value of the radiated field at R.

10 kilometers from a 1 MT surface burst

$$E = \left(\frac{7.2}{10}\right)(1{,}650) \approx 1{,}200 \text{ v/m.}$$

10 kilometers from a 100 KT surface burst

$$E = \left(\frac{5.8}{10}\right)(1{,}650) \approx 950 \text{ v/m.}$$



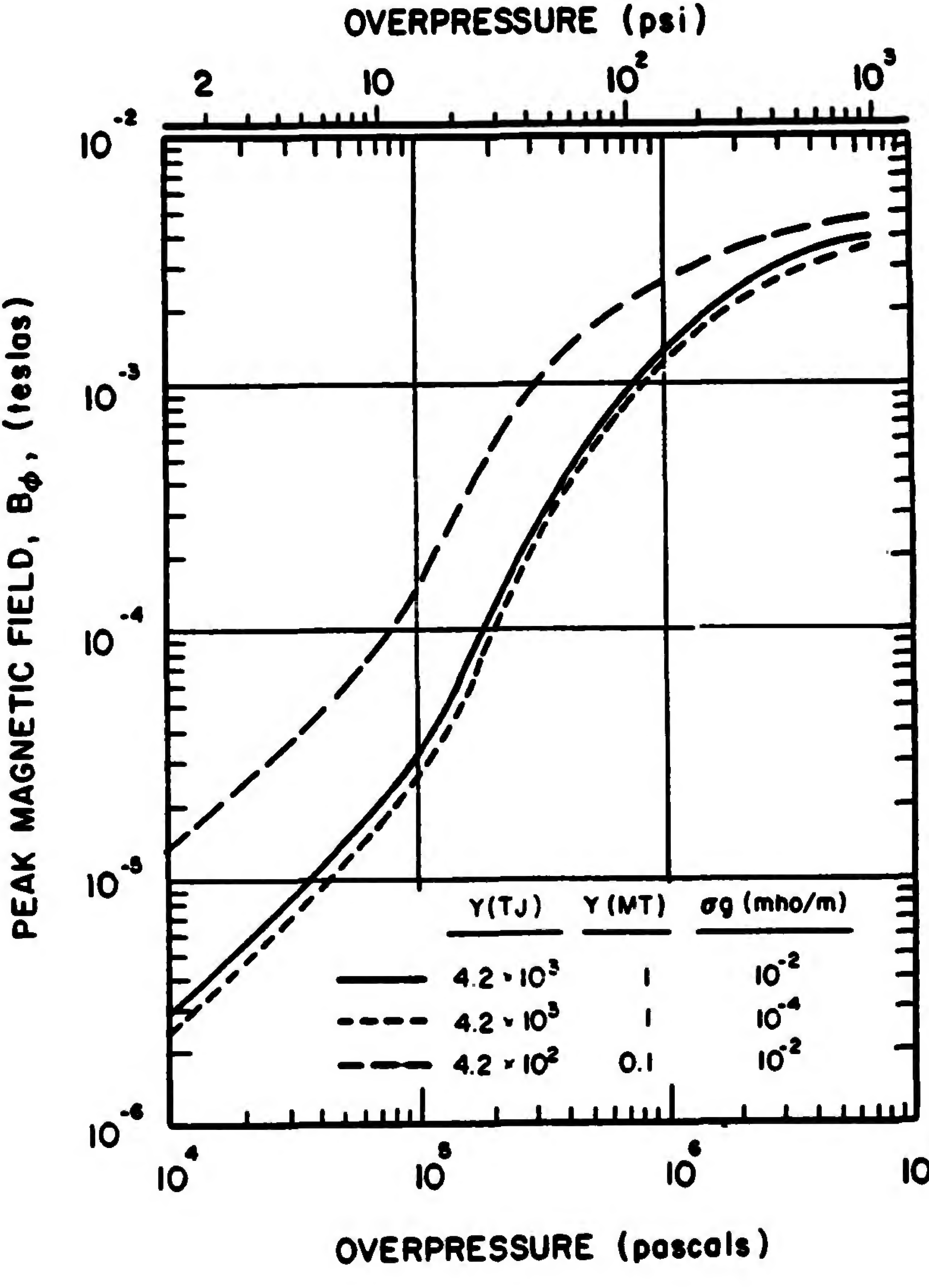


Figure 7-25 Peak Magnetic Field B_φ Versus Overpressure for Varying Ground Conductivities and Yields

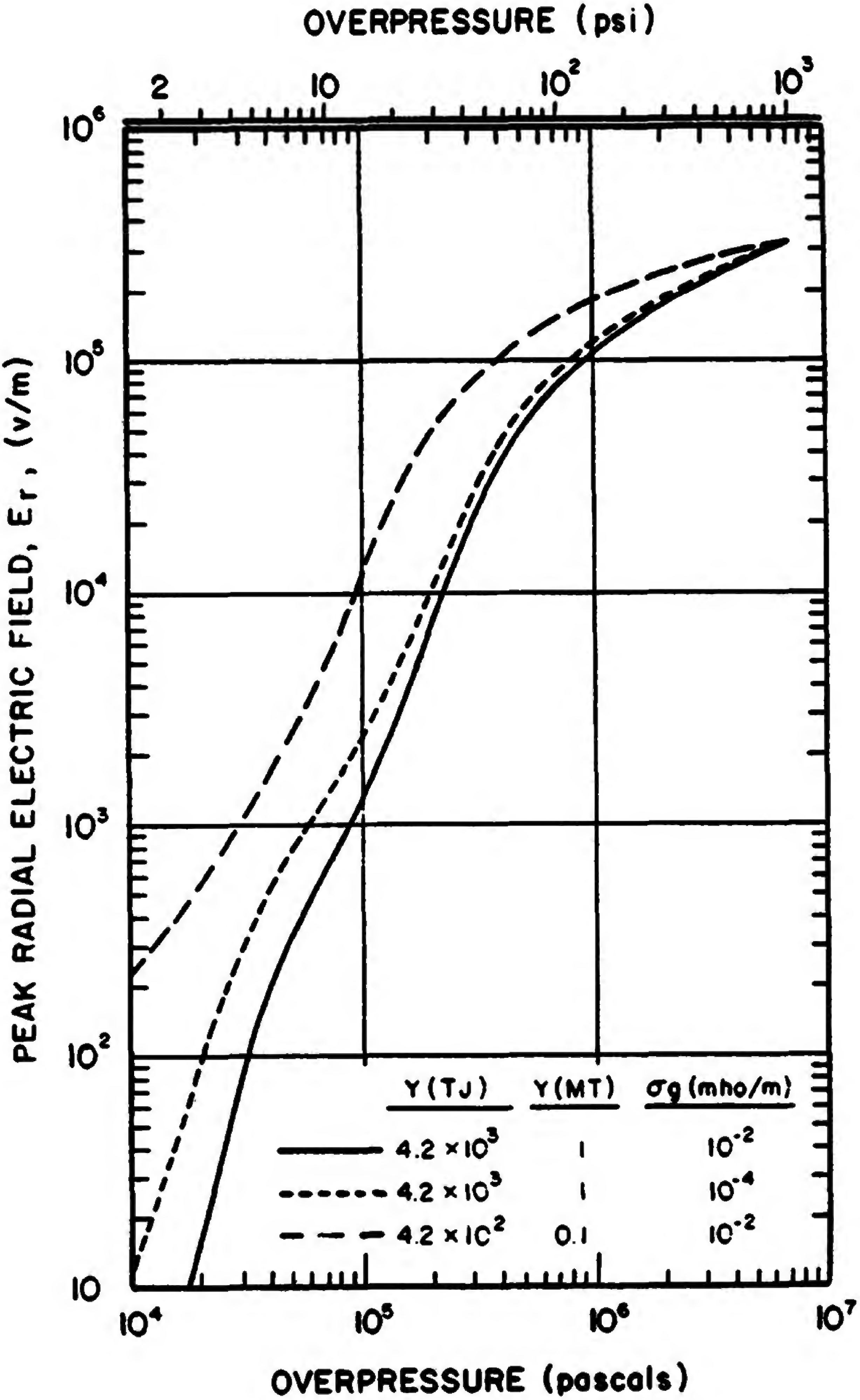


Figure 7-26 Peak Radial Electric Field E_r Versus Overpressure for Varying Ground Conductivities and Yields

SECTION VIII

[redacted] ELECTROMAGNETIC PULSE (EMP) DAMAGE MECHANISMS [redacted]

[redacted] As described in Chapter 7, the nuclear electromagnetic pulse (EMP) is part of a complex environment produced by a nuclear environment. The EMP contains only a very small part of the total energy produced by a nuclear explosion; however, under the proper circumstances, EMP is capable of causing severe disruption and sometimes damage to electrical and electronic systems at distances where all other effects are absent.

[redacted] As with the EMP generation described in Chapter 7, the complexity of the calculation of EMP damage mechanisms requires that heavy reliance be placed on computer code calculations for specific problems, and even these calculations must be supplemented by testing in most cases. Consequently, the information presented herein is largely qualitative and will only serve as an introduction to the subject. More complete treatments of EMP damage mechanisms may be found in the "DNA EMP (Electromagnetic Pulse) Handbook" (see bibliography).

[redacted] Figure 7-18, Chapter 7, provides a matrix that provides some indication of whether EMP constitutes a threat in a given situation relative to the hardness of a system to blast overpressure. This section provides a brief description of EMP energy coupling, component damage, EMP hardening, and testing.

[redacted] ENERGY COUPLING [redacted]

9-56 Basic Coupling Modes [redacted]

[redacted] There are three basic modes of coupling the energy contained in an electromagnetic wave into the conductors that make up an electric or electronic system: electric induction, magnetic induction, and resistive coupling.

[redacted] Electric induction arises as the charges in a conductor move under the influence of the tangential component of an impinging electric field. The overall result is that of a voltage source distribution along the conductor. One such point-voltage source is shown in Figure 9-65 for a simple conducting wire, where the current I is produced as a result of the tangential component $E_{i\ tan}$ of the incident electric field $\bar{E}_i$.

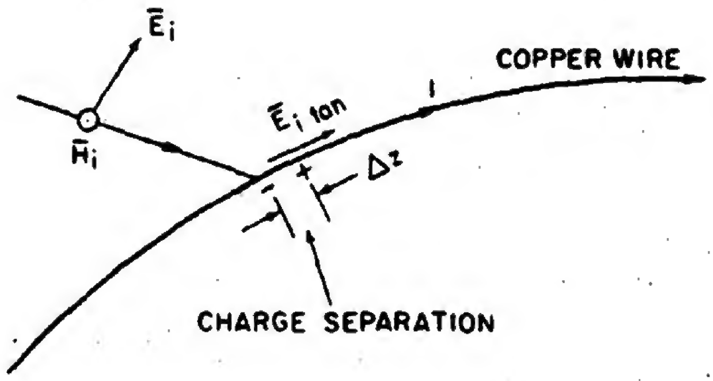


Figure 9-65. [redacted] Electric Induction in a Copper Wire [redacted]

[redacted] Magnetic induction occurs in conductors shaped to form a closed loop when the component of the impinging magnetic field perpendicular to the plane of the loop varies in time, causing charges to flow in the loop. This effect is illustrated in Figure 9-66 for a simple wire loop. Here the magnetic field is shown coming out of the plane of the loop. The loop need not be circular, and magnetic induction may occur with any set of conducting components assembled so as to form a loop.

[redacted] Resistive coupling comes about indirectly as a conductor that is immersed in a conducting medium, such as ionized air or the ground, is influenced by the currents induced in the medium by the other coupling modes. In effect the conductor shares part of the current as an alternate conducting path. This effect is illustrated in Figure 9-67 for the simple case of a

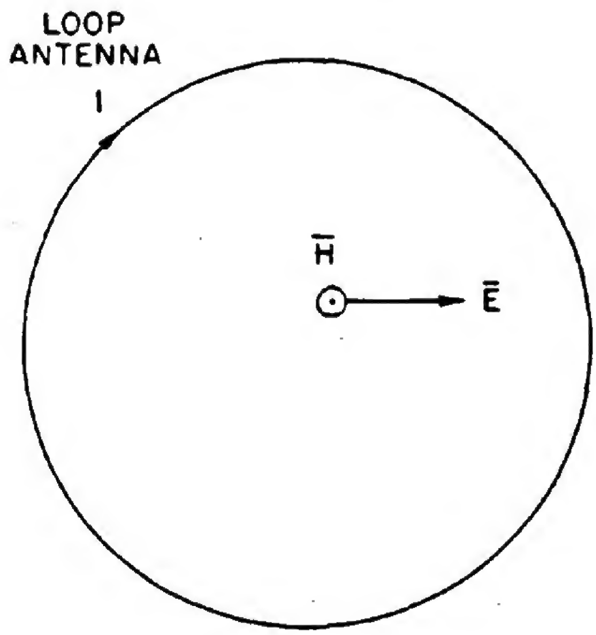


Figure 9-66. [redacted] Magnetic Induction in a Simple Loop [redacted]

[redacted] conductor immersed in the ground. The tangential component of the incident electric field $\bar{E}_i$ induces a current density $\bar{J}$ in the ground. A distributed voltage drop appears along the wire as a result of the current flow in the ground, and this incremental voltage causes current flow I in the wire. Current also may be induced in the wire directly by the tangential component of the refracted electric field, shown as $\bar{E}_g$. The reflected EMP, $\bar{E}_r$, $\bar{H}_r$, is also shown in Figure 9-67. The potential importance of these reflected fields is discussed below.

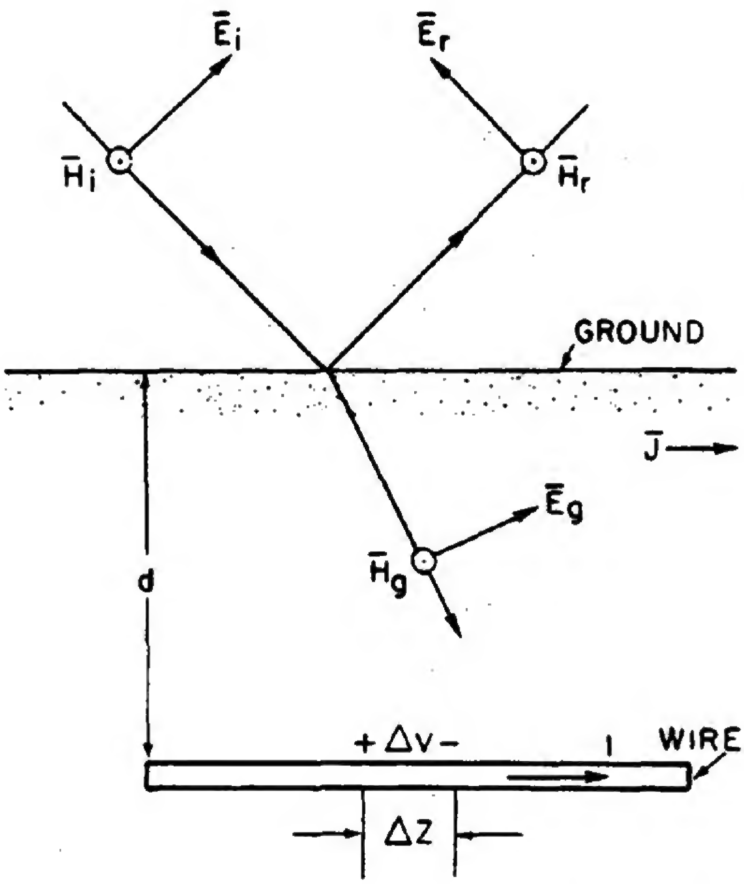


Figure 9-67. [redacted] Resistive Coupling as a Result of Currents in the Ground [redacted]

9-57 Resonant Configurations [redacted]

[redacted] The coupling of energy to a conductor is particularly efficient when the maximum dimension of the conductor configuration is about the same size as the wavelength of the radiation. In this event the voltages that are induced along the conductor at various points are all approximately in phase, so the total voltage induced on the conductor is a maximum. The conductor is said to be resonant, or to behave as an antenna, for frequencies corresponding to near this wavelength. Since EMP has a broad spectrum of frequencies (see Chapter 7), only a portion of this spectrum will couple most efficiently into a specific conductor configuration. Thus, a particular system of interest must be examined with regard to its overall configuration as well as its component configuration. Eash aspect will have characteristic dimensions that determine what part of the pulse (strength and frequencies) constitutes the principal threat.

[redacted] Gross system features that are not normally considered antennas, such as structural features, beams, girders, buried cable, overhead conduit or ducting, wings, fuselage, missile skins, and any wall apertures, must be considered to be potential collectors and conductors of energy into the system.

SANDIA REPORT

SAND2009-3299
Unlimited Release
Printed May 2009

Analysis of Sheltering and Evacuation Strategies for an Urban Nuclear Detonation Scenario

Larry D. Brandt, Ann S. Yoshimura

Executive Summary

A nuclear detonation in an urban area can result in large downwind areas contaminated with radioactive fallout deposition. Early efforts by local responders must define the nature and extent of these areas, and advise the affected population on strategies that will minimize their exposure to radiation. These strategies will involve some combination of sheltering and evacuation actions. Options for shelter-evacuate plans have been analyzed for a 10 kt scenario in Los Angeles.

Results from the analyses documented in this report point to the following conclusions:

- When high quality shelter (protection factor ~10 or greater) is available, shelter-in-place for at least 24 hours is generally preferred over evacuation.
- Early shelter-in-place followed by informed evacuation (where the best evacuation route is employed) can dramatically reduce harmful radiation exposure in cases where high quality shelter is not immediately available.
- Evacuation is of life-saving benefit primarily in those hazardous fallout regions where shelter quality is low and external fallout dose rates are high. These conditions may apply to only small regions within the affected urban region.
- External transit from a low quality shelter to a much higher quality shelter can significantly reduce radiation dose received if the move is done soon after the detonation and if the transit times are short.

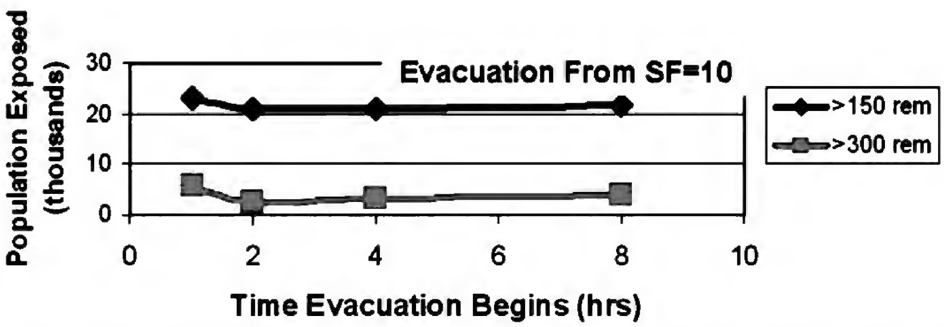
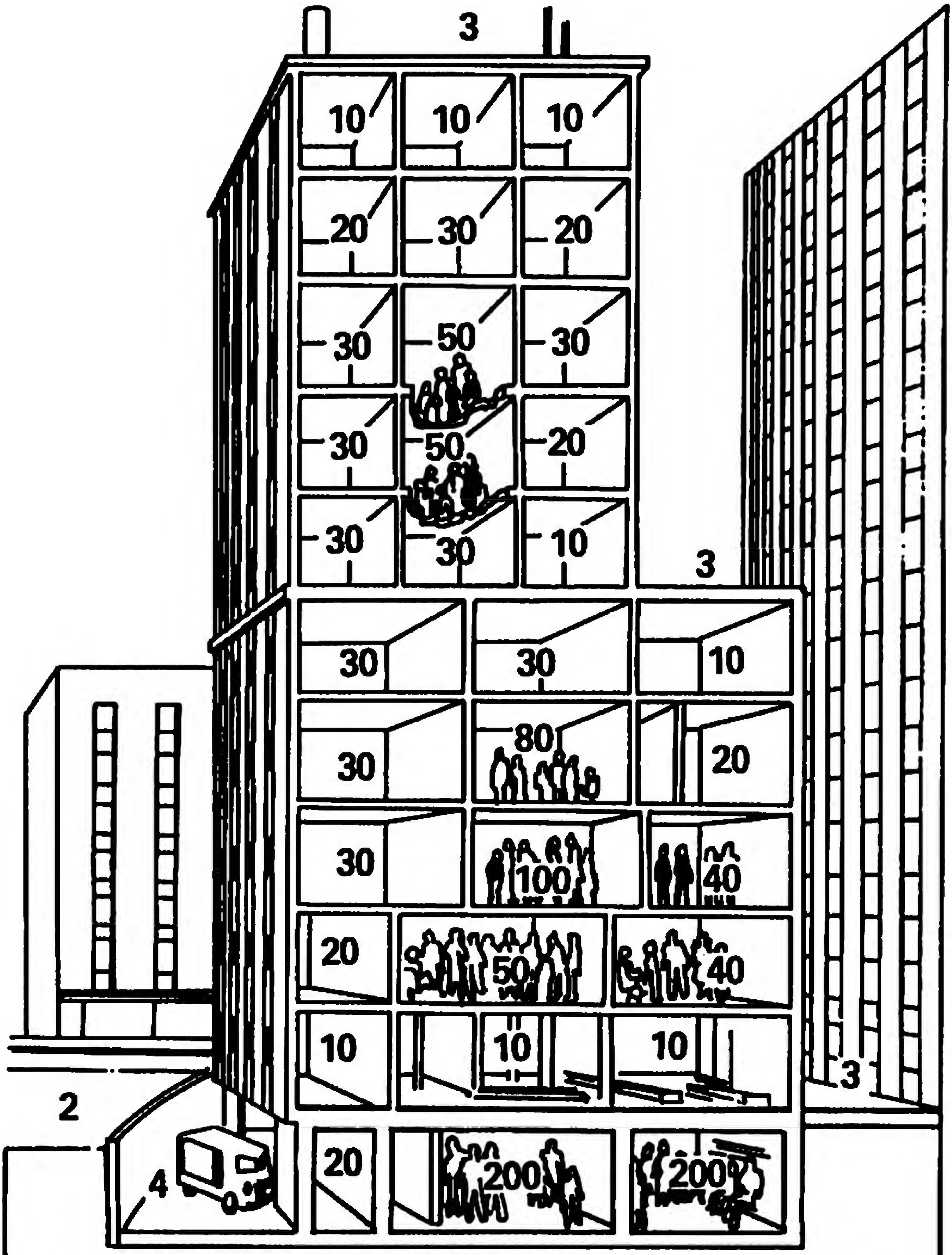


Figure 12. Departure time sensitivities for informed evacuations from shelters with SF=4

Sandia National Laboratories



Radiation protection factors in modern city buildings
DCPA Attack Environment Manual, ch. 6, panel 18

TECHNICAL ANALYSIS REPORT - AFSWP NO. 507

RADIOACTIVE FALL-OUT HAZARDS FROM SURFACE BURSTS OF VERY HIGH YIELD NUCLEAR WEAPONS

by

D. C. Borg
L. D. Gates
T. A. Gibson, Jr.
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MAY 1954

HEADQUARTERS, ARMED FORCES SPECIAL WEAPONS PROJECT
WASHINGTON 13, D. C.

e. Passive defense measures, intelligently applied, can drastically reduce the lethally hazardous areas. A course of action involving the seeking of optimum shelter, followed by evacuation of the contaminated area after a week or ten days, appears to offer the best chance of survival. At the distant downwind areas, as much as 5 to 10 hours after detonation time may be available to take shelter before fall-out commences.

f. Universal use of a simply constructed deep underground shelter, a subway tunnel, or the sub-basement of a large building could eliminate the lethal hazard due to external radiation from fall-out completely, if followed by evacuation from the area when ambient radiation intensities have decayed to levels which will permit this to be done safely.

Table II

Total Isodose Contour: 500r from Fall-out to H+50 Hours

Yield (MT)	15	1	10	60
Downwind extent (mi)	180	52	152	340
Area (mi^2)	5400	470	3880	17,900

FOR RELEASE AT 4:00 P.M. (E.S.T.)
TUESDAY, FEBRUARY 15, 1955

A REPORT

BY THE UNITED STATES ATOMIC ENERGY COMMISSION

ON THE EFFECTS OF HIGH-YIELD NUCLEAR EXPLOSIONS

FALLOUT PATTERN OF 1954 TEST IN THE PACIFIC

19. Data from this test permits estimates of casualties which would have been suffered within this contaminated area if it had been populated. These estimates assume: (1) that the people in the area would ignore even the most elementary precautions; (2) that they would not take shelter but would remain out of doors completely exposed for about 36 hours; and (3) that in consequence they would receive the maximum exposure. Therefore, it will be recognized that the estimates which follow are what might be termed extreme estimates since they assume the worst possible conditions.

PROTECTION AGAINST FALLOUT

26. In an area of heavy fallout the greatest radiological hazard is that of exposure to external radiation. Simple precautionary measures can greatly reduce the hazard to life. Exposure can be reduced by taking shelter and by utilizing simple decontamination measures until such times as persons can leave the area. Test data indicate that the radiation level, i.e., the rate of exposure, indoors on the first floor of an ordinary frame house in a fallout area would be about one-half the level out of doors. Even greater protection would be afforded by a brick or stone house. Taking shelter in the basement of an average residence would reduce the radiation level to about one-tenth that experienced out of doors.

29. If fallout particles come into contact with the skin, hair or clothing, prompt decontamination precautions such as have been outlined by the Federal Civil Defense Administration will greatly reduce the danger. These include such simple measures as thorough bathing of exposed parts of the body and a change of clothing.

30. If persons in a heavy fallout area heeded warning or notification of an attack and evacuated the area or availed themselves of adequate protective measures, the percentage of fatalities would be greatly reduced even in the zone of heaviest fallout.

Extensive lesions in 13 year old boy at 45 days post-exposure. Case 26.

Hyperpigmented raised plaques and bullae on dorsum of feet and toes at 28 days. One lesion on left foot shows deeper involvement. Feet were painful at this time.

Same case as in Plate 5, six months later. Foot lesions have healed with repigmentation, except depigmented spots persist in small areas where deeper lesions were.

Epilation in 7 yr. old girl at 28 days. Case 72.

Same case as in Plate 17, six months after exposure showing complete regrowth of normal hair.

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WT-393
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Operation

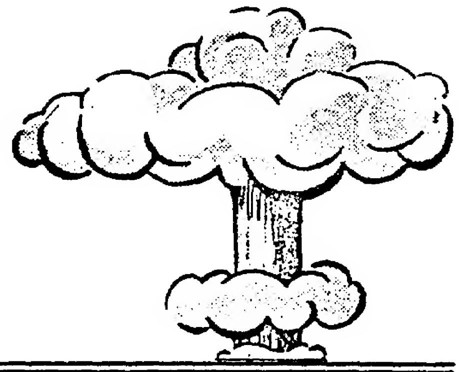
JANGLE

NEVADA PROVING GROUNDS
OCTOBER-NOVEMBER 1951

Project 2.3-2

FOXHOLE SHIELDING OF GAMMA RADIATION

EACH TRANSMITTAL OF THIS DOCUMENT OUTSIDE THE AGENCIES OF THE U.S. GOVERNMENT MUST HAVE PRIOR APPROVAL OF THE DIRECTOR, DEFENSE ATOMIC SUPPORT AGENCY, WASHINGTON, D.C. 20301.



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ATOMIC ENERGY ACT 1946

ARMED FORCES SPECIAL WEAPONS PROJECT
WASHINGTON D.C.

UNCLASSIFIED

SECRET
Security Information

PROJECT 2.3-2

TABLE 3.1

Distribution of Gamma Radiation in Foxholes (Surface Burst)

Range (ft)	Location	Two-man Foxhole			One-man Foxhole		Soil Pipe
2000	36" Above Surface		800 r				
	Surface		700				
	16" Below Surface	230	205	415			
	32" Below Surface	24	58	136			
	48" Below Surface	12.8	22	62			
2500	36" Above Surface		230 r				
	Surface		220				
	16" Below Surface	35	60	85			
	32" Below Surface	7	15	26			
	48" Below Surface	4	8.5	13.3			
3000	36" Above Surface		110 r				73 r
	Surface		90			55	
	16" Below Surface	23	36	55	6.8	6.6	10
	32" Below Surface	7.6	12.4	19.4	2.5	2.4	0.5
	48" Below Surface	2.5	4.8	6.7	1.6	1	0
3500	36" Above Surface		41 r				
	Surface		—				
	16" Below Surface	3	—	9.7			
	32" Below Surface	1.6	2.8	3.4			
	48" Below Surface	.54	.99	1.9			
4000	36" Above Surface		17 r				17 r
	Surface		9.6			—	
	16" Below Surface	1.6	3	5.6	—	0.35	—
	32" Below Surface	0.6	1.12	1.62	—	—	0.17
	48" Below Surface	—	0.54	0.57	0.39	—	—
4500	36" Above Surface		9.8 r				
	Surface		4.6				
	16" Below Surface	1	1.8	3.5			
	32" Below Surface	0.5	0.7	1.04			
	48" Below Surface	0.21	0.4	0.57			
5000	36" Above Surface		4.8 r				
	Surface		2.7				
	16" Below Surface	0.6	0.99	2.95			
	32" Below Surface	0.3	0.5	0.75			
	48" Below Surface	0.17	0.2	0.38			

CHAPTER 5

CONCLUSIONS

5.1 FOXHOLE SHIELDING OF GAMMA RADIATION

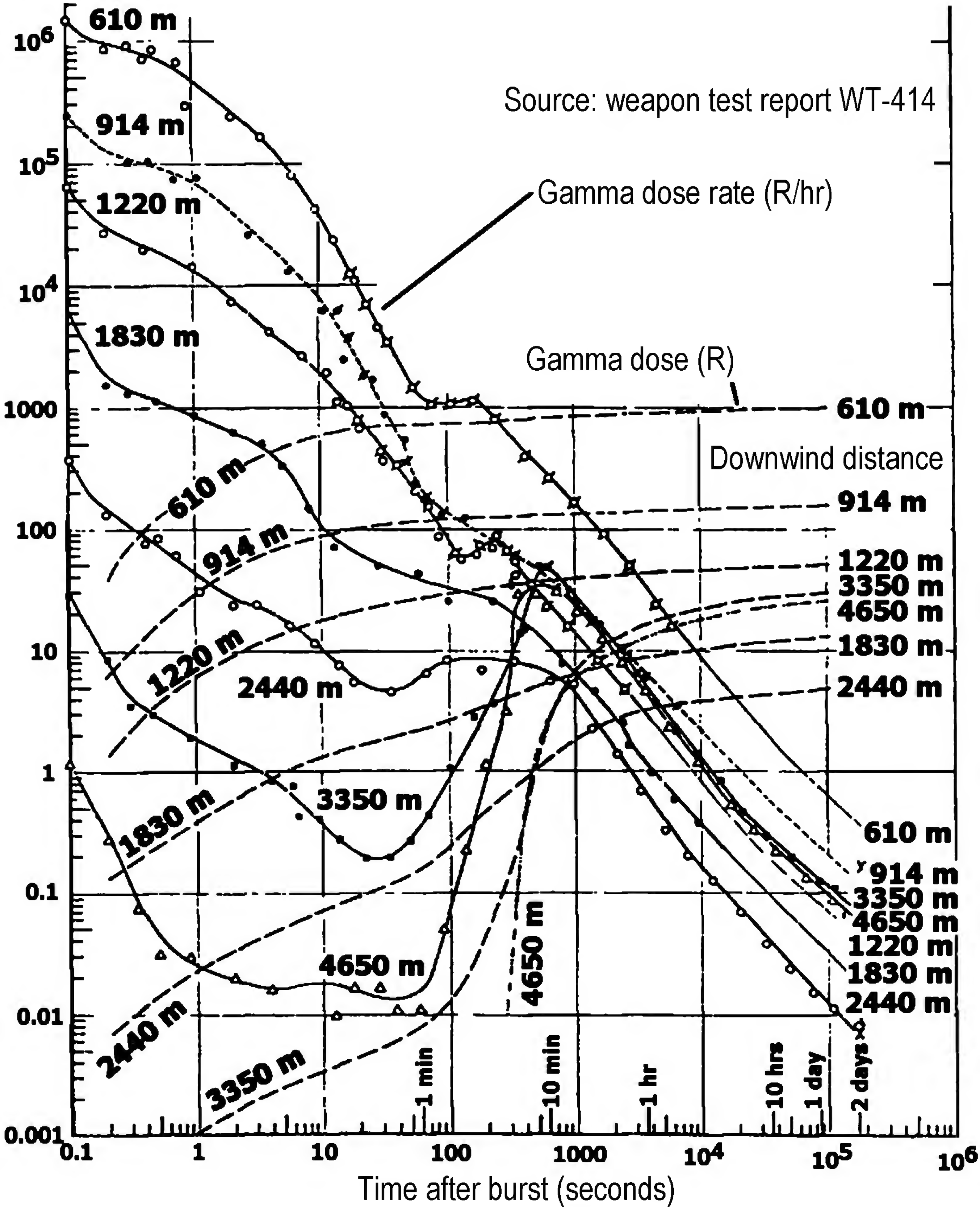
5.1.1 Surface Detonation

Standard foxholes provide excellent protection to personnel from the gamma radiation emitted during the detonation of an atomic weapon on the surface of the ground. The results from the comparatively small sized weapon employed in Operation JANGLE show that 2000 feet from the burst, the location of the closest foxhole doses of about 60r were measured at the bottom of a foxhole, less than 10 per cent of the dose measured 3 feet above the surface of the ground. Due to the location of the foxhole in the crosswind direction, the dose at the bottom was caused primarily by scattered prompt radiation plus a small contribution from the residual activity of the fission products on the surface of the ground. In the downwind direction there would be a contribution from matter that falls out from the cloud into the foxhole in addition to the above mentioned. This fall-out will depend on the wind velocity for a given sized weapon, and although it is expected to increase the dose in the foxholes, especially in those located close to the detonation, it is relatively unimportant in comparison to the prompt and residual activity since it can be easily shoveled out of the foxhole in a short time.

5.1.2 Underground Detonation

With the possible exception of those located in the area close to the point of detonation where extensive fall-out occurs, foxholes also provide effective shielding in the case of an underground detonation. Even within this area of extensive fall-out, which at Operation JANGLE extended approximately 2000 feet, the high doses recorded in the foxholes could be greatly reduced by digging out the radioactive matter that fell into the hole. It is highly probable that one-half the doses recorded in the foxholes located within 2500 feet of the detonation at Operation JANGLE were directly attributable to this type of fall-out and most likely a higher percentage at distances greater than 2500 feet.

1.2 kt SUGAR test (Nevada surface burst)



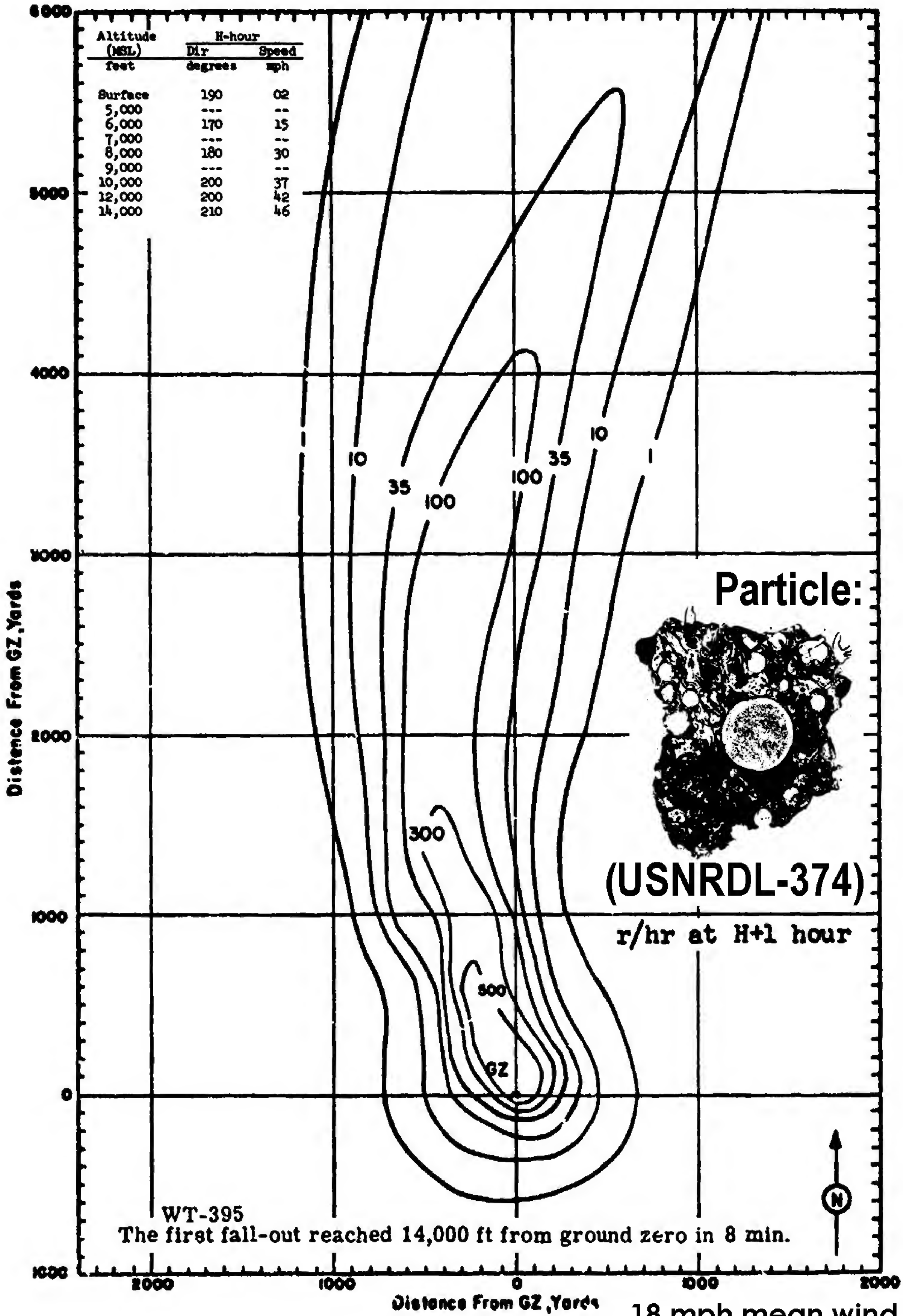
1.2 kt JANGLE - Sugar Surface burst 19 Nov 1951

CLOUD TOP HEIGHT: 15,000 ft MSL

CRATER DATA: Diameter: 90 ft; Depth: 21 ft — maximum dose rate: 7500 r/hr at H+1 hour at crater lip

Maximum dose rate		Maximum contour distance from GZ (ft)			Contour area (sq mi)		
Value (r/hr)	Distance from GZ (ft)	500 r/hr	300 r/hr	100 r/hr	500 r/hr	300 r/hr	100 r/hr
540	900	2200	4900	12,500	0.05	0.15	0.55

Laurino, R. K., and I. G. Poppoff, 1953: *Contamination patterns at Operation JANGLE*. U. S. Nav. Rad. Def. Lab. Rep. USNRDL-399, 28 pp.



18 mph mean wind speed

Robbins, Charles; et al. "Airborne Particle Studies, JANGLE Project 2.5a-1." (In: Operation JANGLE, Particle Studies, WT-371-EX, 417 pages.) Army Chemical Center. Washington, D. C.: AFSWP. WT-394-EX. October 1979. 198 Pages. AD/A995 072.

OPERATION JANGLE

Project 2.5a-1

AIRBORNE PARTICLE STUDIES

by

Lt. Col. Charles Robbins
Chemical Corps

Major Hugh R. Lehman
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David R. Powers
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James D. Wilcox
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July 1952

CHEMICAL AND RADIOLOGICAL LABORATORIES
Army Chemical Center, Maryland

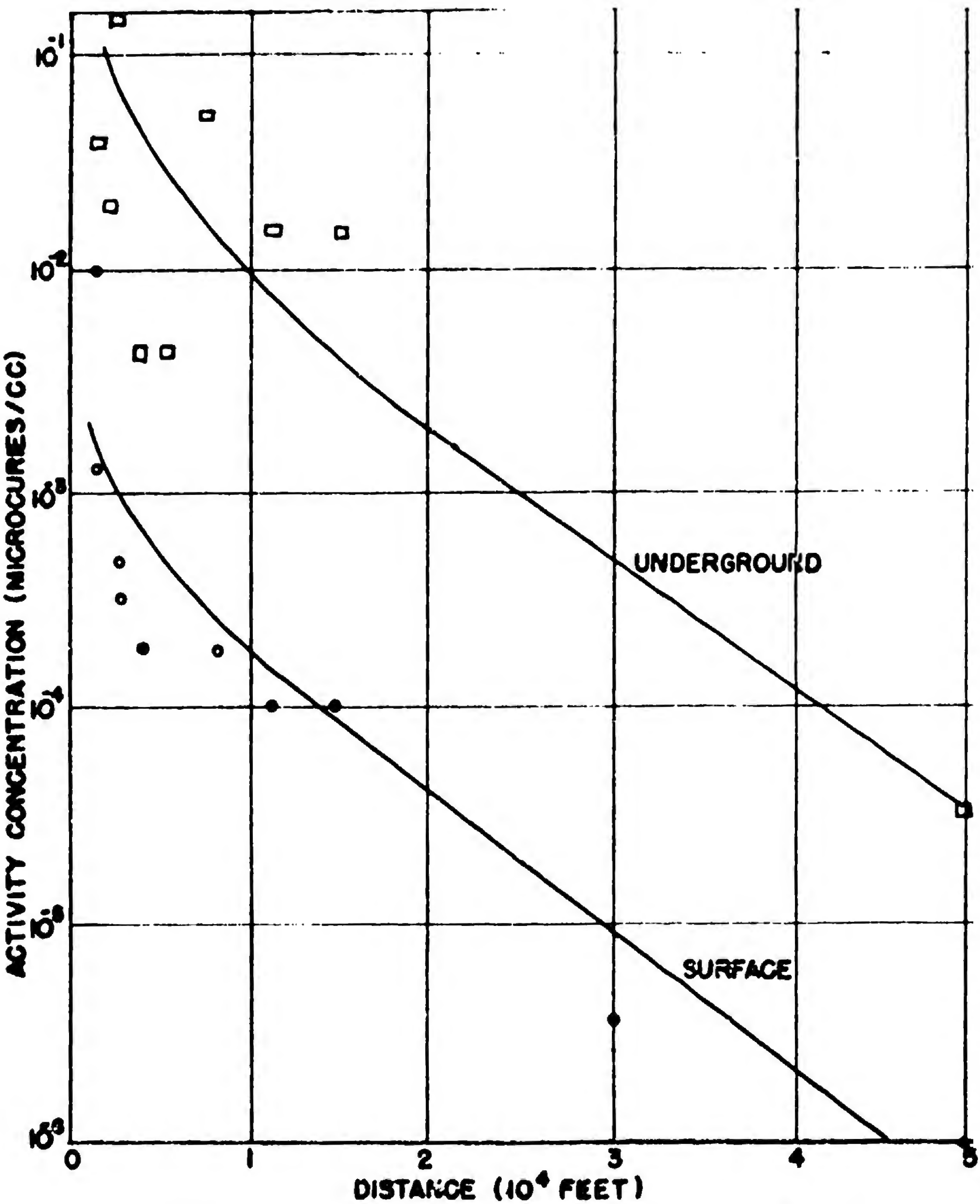

Figure 5.1 Concentration of Activity in the Cloud as a Function of Distance on the Downwind Leg. Filter Sampler Data. Activity was corrected to time at which cloud passed each station.

8.9 INHALATION STUDIES

Dogs and sheep were exposed on the ground surface and in foxholes at distances of 2500 to 8000 feet in the predicted downwind direction from each shot. The purpose of the exposure was to allow the assessment of hazards due to inhalation of radioactive dusts associated with these detonations and to compare internal and external radiation dosages.

Total body activity for animals exposed in the underground test ranged from 2 to 31 microcuries corrected to time of sacrifice. For lung tissue, integrated dosage due to beta emission ranged between 0.2 and 9.0 rep. Radioautographs of lung tissues indicated the presence of a few alpha emitting particles. Bone analyses indicated some uptake of Ba^{140} and Sr^{90}.

The amounts of activity taken up by the combined action of inhalation and ingestion are not considered to be physiologically significant even for animals receiving cumulative external gamma radiation dosages up to several thousand roentgens.

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9.8 CLOTHING DECONTAMINATION AND EVALUATION OF LAUNDRY METHODS

Standard and special U. S. Army Quartermaster Corps laundering methods and standard laundry equipment were evaluated for field decontamination of clothing and selected fabrics. No clothing worn by personnel became contaminated to a significant degree during this operation. Therefore, this project was carried out with clothing deliberately contaminated with radioactive material from the fall-out area.

The project evaluated the standard and several special laundering formulae, various types of clothing materials, and monitoring instruments (Project 6.7). The significant result of this project is the indication that clothing contamination resulting from work in areas contaminated by atomic bomb detonations will not produce even minor injury to personnel. This conclusion is based on consideration of the data on saturation values of deliberate clothing contamination reduced to one hour after detonation. The resultant exposure to personnel would be less than that required to produce even slight skin irritation (comparable to mild sunburn). Other conditions, such as muddy terrain and much higher specific activity, could increase the amount of contamination received by clothing, but an increase in level of several orders of magnitude would be required to produce injury. In these cases it is certain that routine standards of cleanliness would effectively prevent injury from this cause.

PHYSICAL, CHEMICAL, AND RADIOLOGICAL PROPERTIES OF SLURRY PARTICULATE FALLOUT COLLECTED DURING OPERATION REDWING

U.S. NAVAL RADIOLOGICAL DEFENSE LABORATORY
San Francisco 24, California

Research and Development Technical Report USNRDL-TR-170

5 May 1957

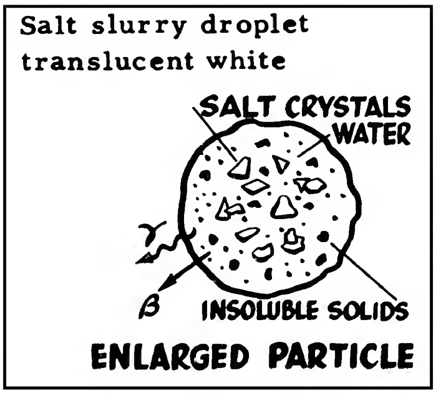
by

N.H. Farlow
W.R. Schell

Table 1 Slurry Fallout Particle Data

Time of Arrival Interval (H+hr)	Ship station	No. of Particles Measured	Average NaCl Mass (μg)	Average H_2O Mass (μg)	Average Density ±Std.Dev. (g/cc)	Average Diameter[(a)] ±Std.Dev. (μ)
			Navaho			
1 to 3	YFNB-13	5to20	7.77	7.94	1.38±0.04	272±14
3 to 5	YAG-39	9to14	7.62	4.49	1.50±0.1	229±24
5 to 6	LST-611	14	1.61	1.83	1.41±0.04	166±6
7 to 9	YAG-40	4to10	1.25	1.08	1.45±0.04	142±22
9 to 10	YAG-40	5to23	0.44	0.60	1.31±0.02	110±5
10 to 11	YAG-40	11to15	0.66	0.50	1.43±0.03	111±4
11 to 12	YAG-40	33	0.30	0.44	1.32±0.01	94±4
12 to 13	YAG-40	28	0.31	0.31	1.37±0.01	96±2
13 to 14	YAG-40	6	0.17	0.27	1.28±0.02	86±7
14 to 15	YAG-40	5	0.10	0.18	1.30±0.03	75±2
15 to 18	YAG-40	13to14	0.06	0.32	1.15±0.02	84±4
Totals		133 to 182			1.35±0.01	

(a) The diameter of the spherical slurry droplet at the time of arrival



WATER SURFACE BURST

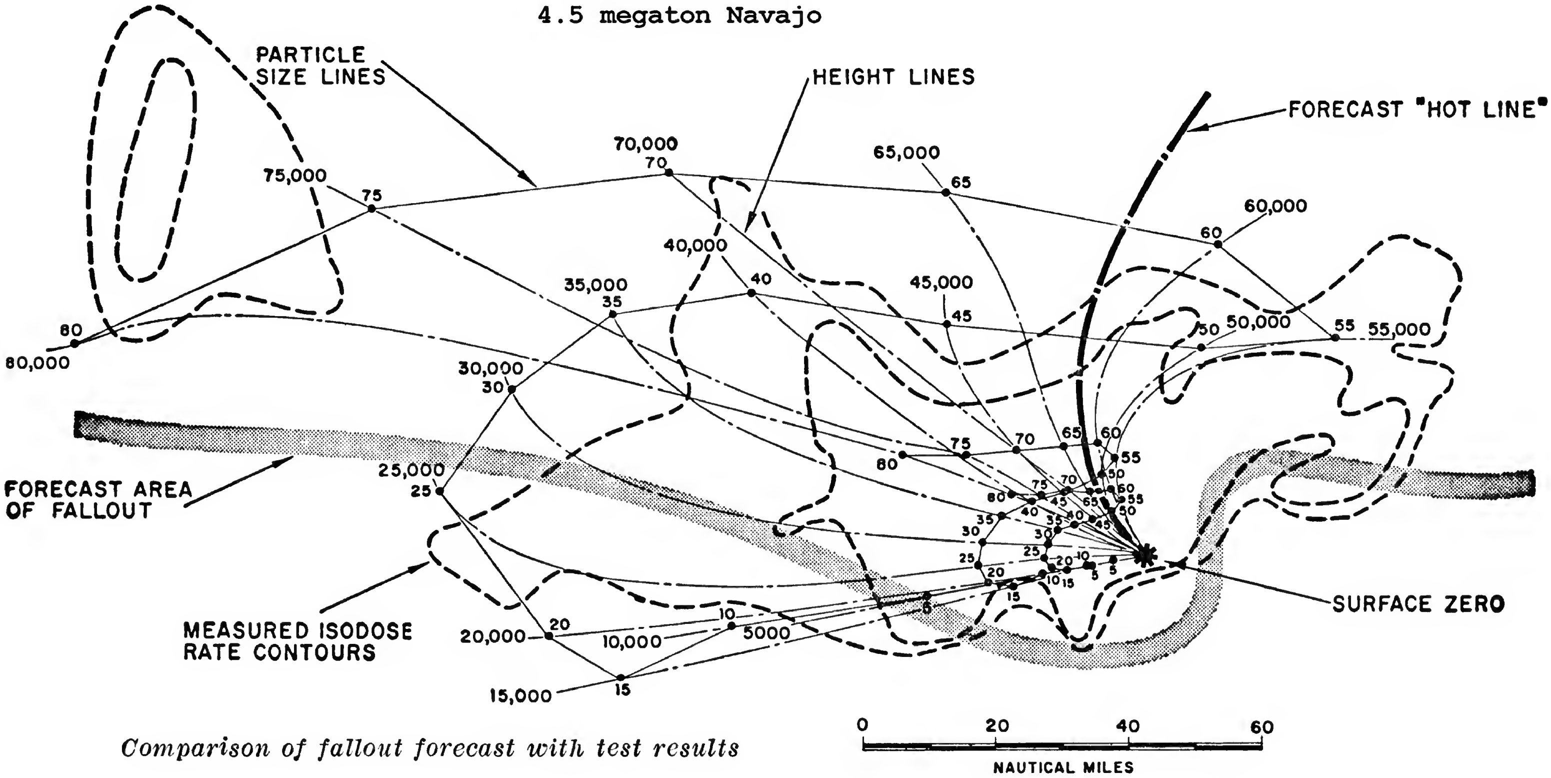
A FALLOUT FORECASTING TECHNIQUE WITH RESULTS OBTAINED AT THE ENIWETOK PROVING GROUND

E. A. Schuert, USNRDL TR–139, United States Naval Radiological Defense Laboratory, San Francisco, Calif.

Time variation of the winds aloft

In most of the observations made at the Eniwetok Proving Ground, the winds aloft were not in a steady state. Significant changes in the winds aloft were observed in as short a period as 3 hours. This variability was probably due to the fact that proper firing conditions which required winds that would deposit the fallout north of the proving ground, occurred only during an unstable synoptic situation of rather short duration.

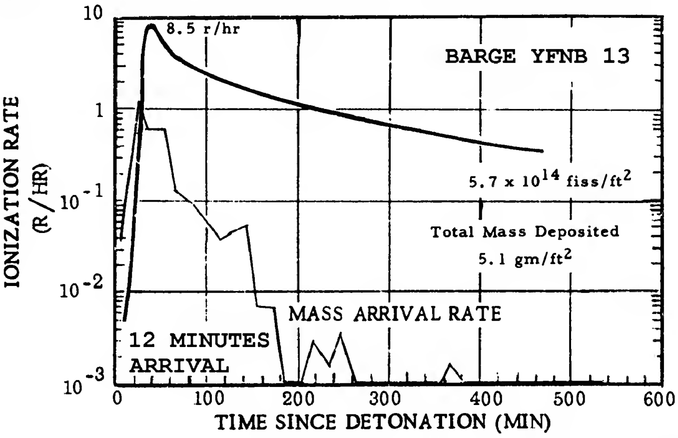
4.5 megaton Navajo



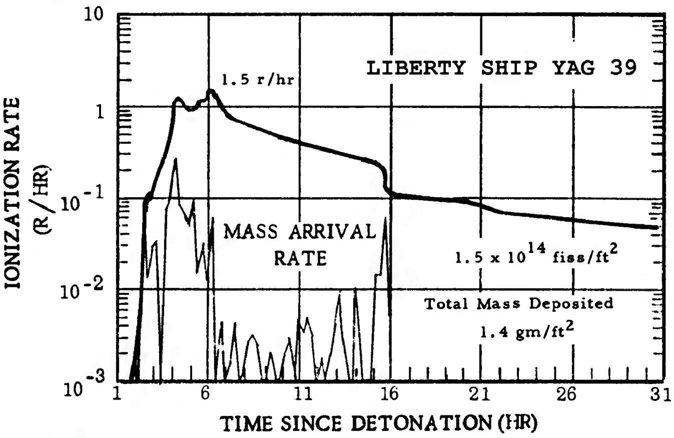
Comparison of fallout forecast with test results

HEIGHT LINE = DESTINATIONS FOR A FIXED HEIGHT OF ORIGIN FOR VARIOUS SIZES
SIZE LINE = DESTINATIONS FOR A FIXED PARTICLE SIZE FROM VARIOUS HEIGHTS
HOT LINE = HEIGHT LINE FROM BASE OF MUSHROOM DISC (MAXIMUM FALLOUT)

4.5 MT NAVAJO (5% FISSION), 7.54 STAT. MILES W



4.5 MT NAVAJO (5% FISSION), 21.0 STAT. MILES N



Triffet, T. and LaRiviere, P.D.; Characterization of Fallout, Project 2.63

LAND SURFACE BURST

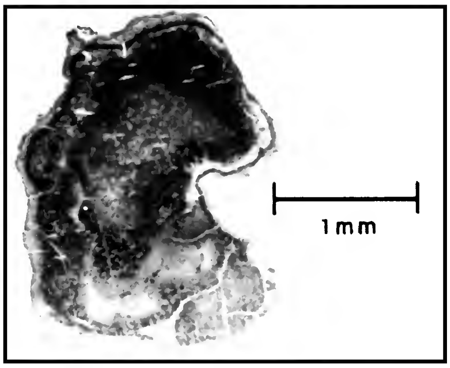
A Fallout Forecasting Technique With Results Obtained at the Eniwetok Proving Ground

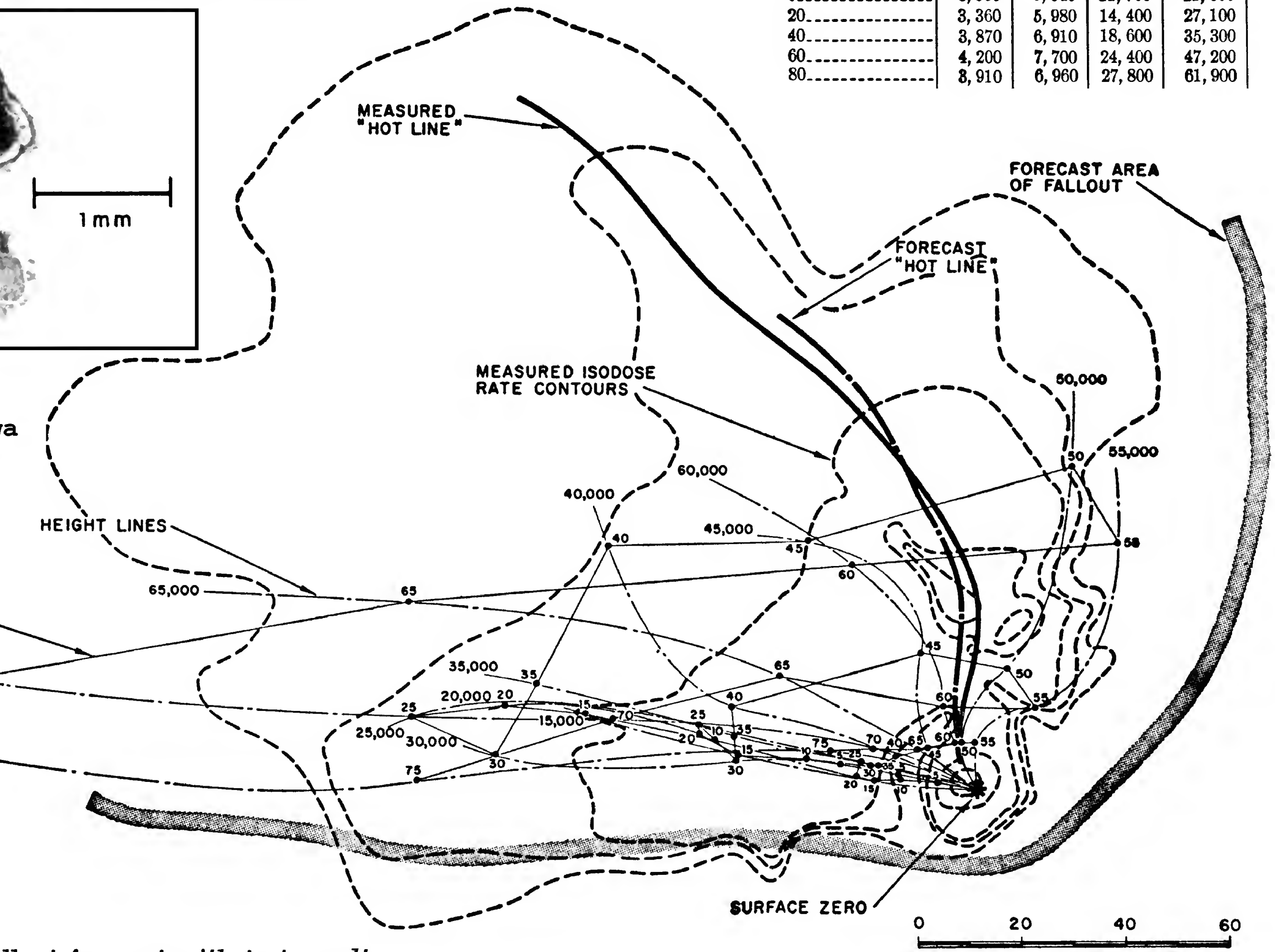
E. A. Schuert, USNRDL TR–139, United States Naval Radiological Defense Laboratory, San Francisco, Calif.

2.36 g/cu cm irregular in shape

Falling speeds (feet/hour)

Altitude	75 μ	100 μ	200 μ	350 μ
0	3,060	5,040	11,700	21,600
20	3,360	5,980	14,400	27,100
40	3,870	6,910	18,600	35,300
60	4,200	7,700	24,400	47,200
80	3,910	6,960	27,800	61,900





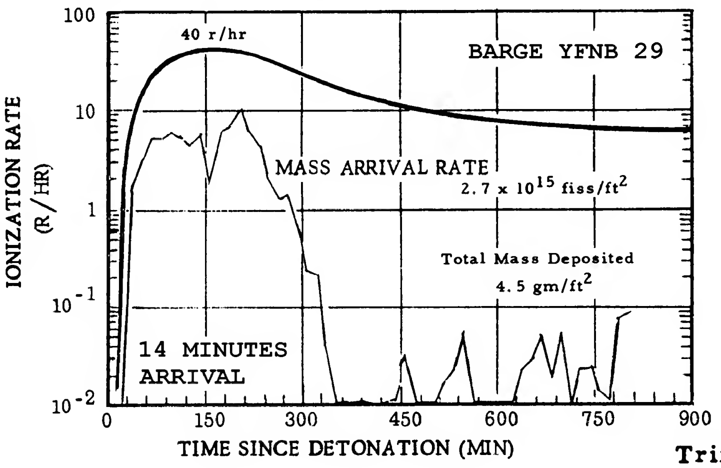
Comparison of fallout forecast with test results

HEIGHT LINE = DESTINATIONS FOR A FIXED HEIGHT OF ORIGIN FOR VARIOUS SIZES

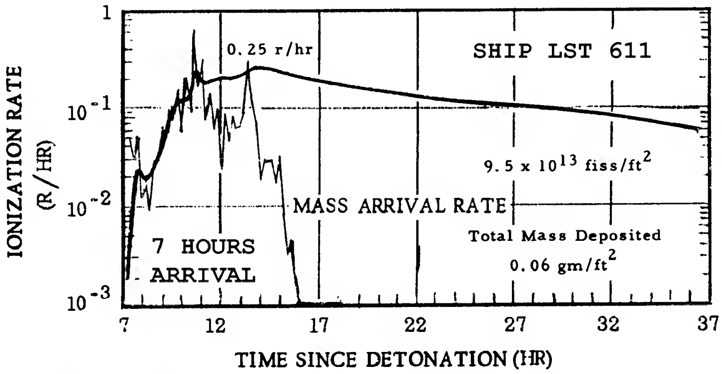
SIZE LINE = DESTINATIONS FOR A FIXED PARTICLE SIZE FROM VARIOUS HEIGHTS

HOT LINE = HEIGHT LINE FROM BASE OF MUSHROOM DISC (MAXIMUM FALLOUT)

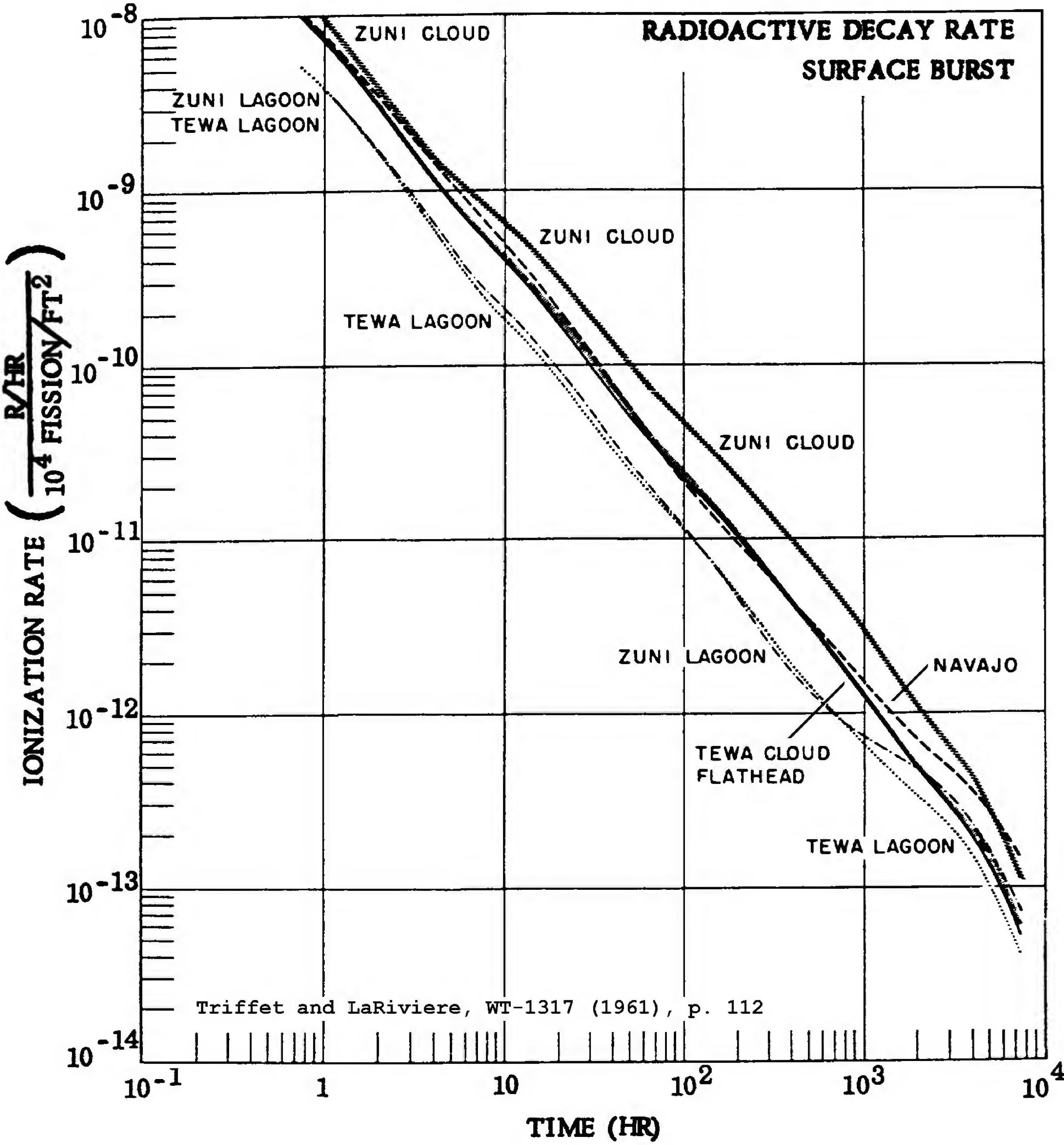
5 MT TEWA (87% FISSION), 7.84 STAT. MILES WSW



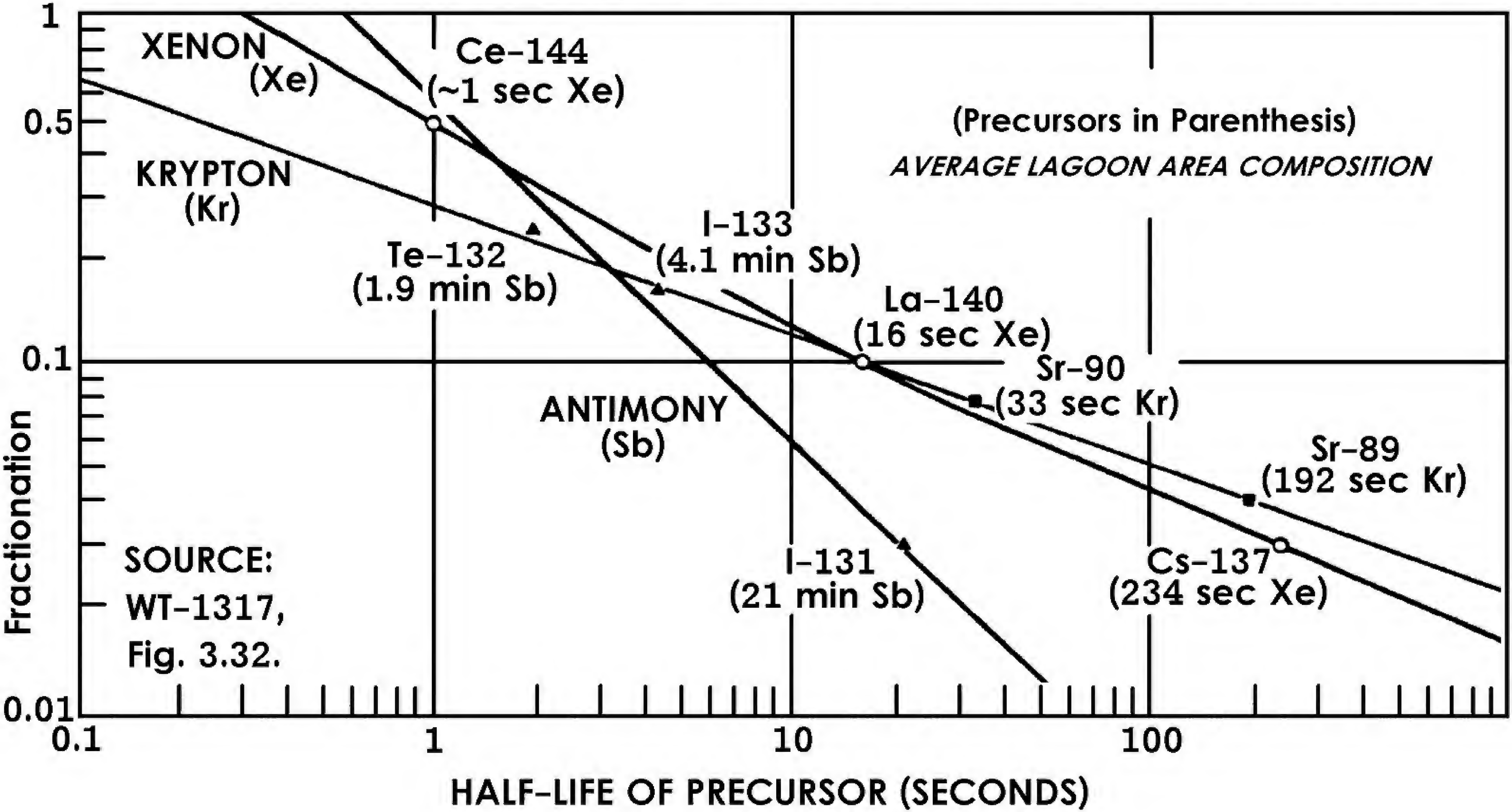
5 MT TEWA (87% FISSION), 59.3 STAT. MILES NW



Triffet, T. and LaRiviere, P. D.; Characterization of Fallout


RADIOACTIVE DECAY RATE
SURFACE BURST
ZUNI CLOUD
ZUNI LAGOON
TEWA LAGOON
ZUNI CLOUD
TEWA LAGOON
ZUNI CLOUD
ZUNI LAGOON
NAVAJO
TEWA CLOUD
FLATHEAD
TEWA LAGOON
Triffet and LaRiviere, WT-1317 (1961), p. 112
IONIZATION RATE (R/HR / 10^4 FISSION/FT^2)
TIME (HR)
10^-8
10^-9
10^-10
10^-11
10^-12
10^-13
10^-14
10^-1
1
10
10^2
10^3
10^4

3.53 Mt coral surface burst REDWING–ZUNI: close–in fallout fractionation factors



Measured relationship between the fusion yield of the nuclear explosive and the quantity of neutron-induced activities in the fallout*

Test		*Redwing-Navajo*	*Redwing-Zuni*	*Redwing-Tewa*	
Design		Lead pusher	Lead pusher	U-238 pusher	
Total yield		4.5 Mt	3.53 Mt	5.01 Mt	
% Fission		5	15	87	
% Fusion		95	85	13	
Nuclide	*Half life*	*Abundance of nuclide in bomb fallout, atoms per bomb fission*			*R1***
Na-24	15 hours	0.0314	0.0109	0.00284	1284.7
Cr-51	27.2 days	0.0120	0.0017	0.00030	0.280
Mn-54	304 days	0.10	0.011	0.00053	0.614
Mn-56	2.58 hours	0.094		0.00053	2668
Fe-59	45.2 days	0.0033	0.00041	0.00017	6.19
Co-57	272 days	0.00224	0.0031	0.00018	0.113
Co-58	71 days	0.00193	0.0036	0.00029	3.11
Co-60	5.27 years	0.0087	0.00264	0.00081	0.299
Cu-64	12.8 hours	0.0278	0.0090	0.0023	89.5
Sb-122	2.75 days		0.219***		38.4
Sb-124	60 days		0.073***		6.92
Ta-180	8.15 hours	0.038	0.0411		35.9
Ta-182	114 days	0.038	0.0326	0.01	2.67
Pb-203	52 hours	0.0993	0.050	0.000018	26.0
U-237	6.75 days		0.20	0.20	6.50
U-239	23.5 minutes	0.085	0.31	0.36	173
Np-239	56.4 hours	0.085	0.31	0.36	14.9*+*
U-240	14.1 hours		0.005	0.09	0 (no gamma rays)
Np-240	7.3 minutes		0.005	0.09	150

*Dr Terry Triffet and Philip D. LaRiviere, "Characterization of Fallout, Operation Redwing, Project 2.63," U.S. Naval Radiological Defense Laboratory, 1961, report WT-1317, Table B.22. Data on U-238 capture nuclides is from USNRDL-466, Table 6, in combination with WT-1315, Table 4.1.

**Triffet's 1961 values for the gamma dose rate at 1 hour after burst at 3 ft above an infinite, smooth, uniformly contaminated plane, using an ideal measuring instrument with no shielding from the person holding the instrument, from 1 atom/fission of induced activity, (R/hr)/(fission kt/square stat mile).

***The Zuni bomb contained a lot of antimony (Sb), which melts at 903.7K and boils at 1650K. The abundances of Sb-122 and Sb-124 given in the table are for unfractionated cloud samples; because of the low boiling point of antimony, it was fractionated in close-in fallout, so the abundances of both Sb-122 and Sb-124 in the Zuni fallout at Bikini Lagoon were 8.7 times lower than the unfractionated cloud fallout.

*+*Note that Np-239 at 1 hour after burst is still forming as the decay product of U-239.

Measured capture to fission ratios in nuclear tests*

Test shot	*Weapon design*	*Yield*	*Fission %*	*Number of neutron capture atoms per fission*		
				U-239 & Np-239	*U-237*	*U-240 & Np-240*
Jangle-Sugar	U238 reflector	1.2 kt	100	0.59		
Jangle-Uncle	U238 reflector	1.2 kt	100	0.59		
Castle-Bravo	U238 pusher	14.8 Mt	68	0.56	0.10	0.14
Castle-Romeo	U238 pusher	11 Mt	64	0.66	0.10	0.23
Castle-Koon	U238 pusher	110 kt	91	0.72	0.10	
Castle-Union	U238 pusher	6.9 Mt	72	0.44	0.20	0.07
Redwing-Zuni		3.53 Mt	15	0.31	0.20	0.005
Redwing-Tewa		5.01 Mt	87	0.36	0.20	0.09
Diablo	U238 in core**	18 kt	100	0.10		
Shasta	U238 in core**	16 kt	100	0.10		
Coulomb C	U238 in core**	0.6 kt	100	0.03		

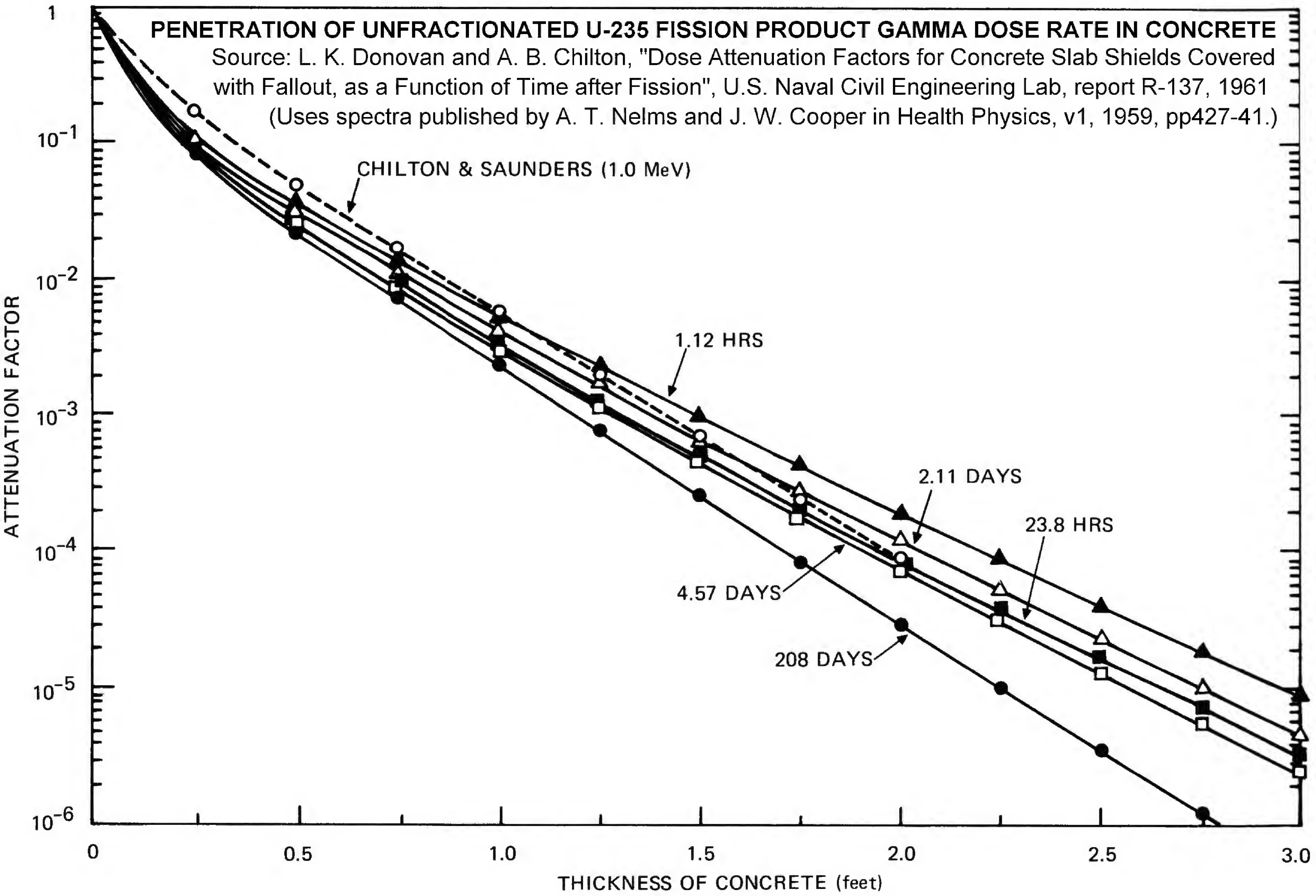
* Data is derived from all analyses of aircraft cloud fallout samples and deposited fallout samples in Dr Carl F. Miller, U.S. Naval Radiological Defense Laboratory, report USNRDL-466 (1961), Table 6.

**In these Plumbbob weapon tests, there was no U238 reflector and the only U238 in the bomb was that contained in the fissile core as an impurity.

Spectrum of fission product gamma rays from the thermonuclear neutron fission of U-238 as a function of the degree of fractionation for two different times after detonation (Glenn R. Crocker, *Radiation Properties of Fractionated Fallout; Predictions of Activities, Exposure Rates and Gamma Spectra for Selected Situations,* U.S. Naval Radiological Defense Laboratory, USNRDL-TR-68-134, 27 June 1968, 287 pp.)

Gamma ray energy, MeV	Gamma ray spectrum at 1 hour after burst				Gamma ray spectrum at 1 week after burst			
	Sr-89 abundance (relative to unfractionated fallout)				Sr-89 abundance (relative to unfractionated fallout)			
	10% $R_{89,95} = 0.1$	50% $R_{89,95} = 0.5$	100% $R_{89,95} = 1$*	200% $R_{89,95} = 2$	10% $R_{89,95} = 0.1$	50% $R_{89,95} = 0.5$	100% $R_{89,95} = 1$*	200% $R_{89,95} = 2$
0-0.5	0.396	0.354	0.350	0.304	0.695	0.662	0.678	0.637
0.5-1	0.385	0.379	0.363	0.357	0.262	0.270	0.245	0.265
1-1.5	0.1605	0.1863	0.1914	0.232	0.01339	0.01358	0.01218	0.01273
1.5-2	0.0327	0.0466	0.0558	0.0596	0.0287	0.0519	0.0591	0.0790
2-2.5	0.01628	0.0203	0.0279	0.0290	0.001114	0.001313	0.001268	0.001445
2.5-3	0.00429	0.00717	0.01192	0.01305	0.001372	0.00253	0.00291	0.00388
3-3.5	0.00340	0.00301	0.00267	0.00273	0.0000260	0.0000490	0.0000564	0.0000760
3.5-4	0.001425	0.001187	0.001705	0.00214	0	0	0	0
Total:	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Relative gamma activity	0.547	0.756	1*	1.25	0.563	0.768	1*	1.12
Mean energy, MeV	0.710	0.767	0.807	0.856	0.444	0.486	0.483	0.526

*Unfractionated ($R_{89,95} = 1$) fission product composition relative gamma activity is normalized to 1 unit/second. The presence of neutron induced activities in U-238 like Np-239, U-240, and U-237 due to non-fission capture is not included, and would further soften the fractionated fallout spectra, since they emit low energy gamma rays.


PENETRATION OF UNFRACTIONATED U-235 FISSION PRODUCT GAMMA DOSE RATE IN CONCRETE
Source: L. K. Donovan and A. B. Chilton, "Dose Attenuation Factors for Concrete Slab Shields Covered with Fallout, as a Function of Time after Fission", U.S. Naval Civil Engineering Lab, report R-137, 1961
(Uses spectra published by A. T. Nelms and J. W. Cooper in Health Physics, v1, 1959, pp427-41.)
CHILTON & SAUNDERS (1.0 MeV)
1.12 HRS
2.11 DAYS
23.8 HRS
4.57 DAYS
208 DAYS
ATTENUATION FACTOR
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
0
0.5
1.0
1.5
2.0
2.5
3.0
THICKNESS OF CONCRETE (feet)

RADIOACTIVE FALLOUT AND ITS EFFECTS ON MAN pages 1689-1691

A. E. R. E. HP/R 2017

ATOMIC ENERGY RESEARCH ESTABLISHMENT

The Radiological Dose to Persons in the U. K. Due to Debris From Nuclear Test Explosions Prior to January 1956

By N. G. Stewart, R. N. Crooks, and Miss E. M. R. Fisher

Activity from Neutron Capture

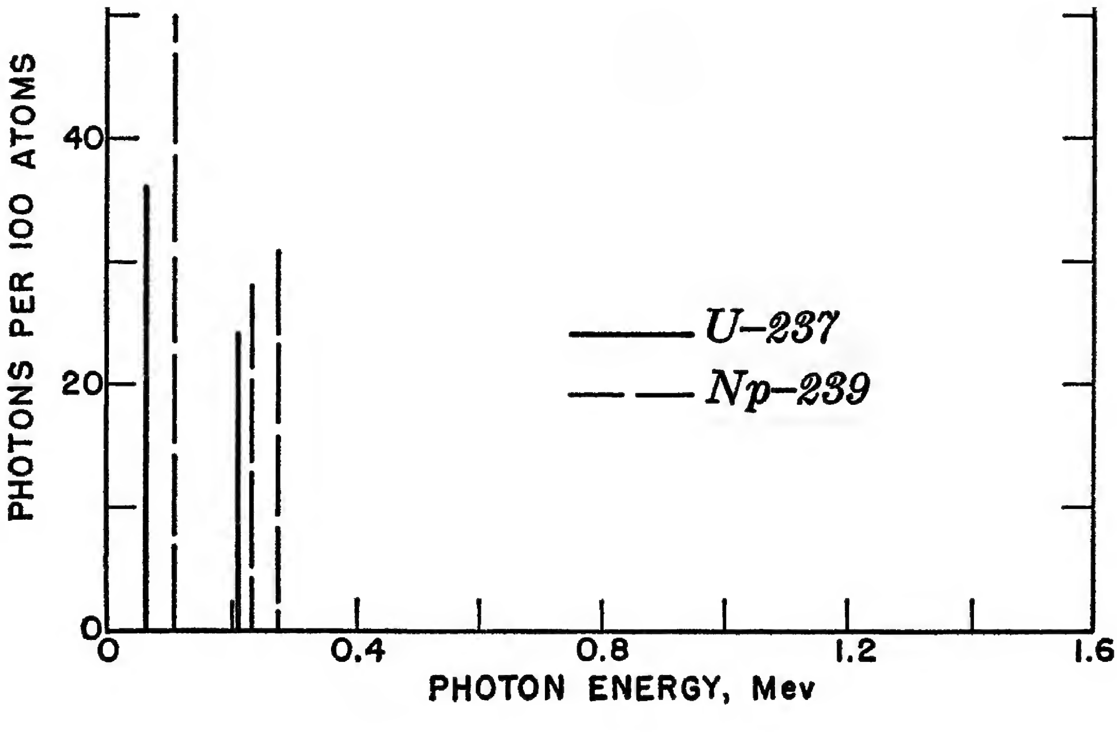
Although several different radioactive elements may be created by the capture of neutrons in materials close to the reacting core of a weapon, the only significant reactions to produce gamma-ray emitters are those associated with the natural uranium which may be used as the tamper material of the bomb.

neutron (low energy) + U-238 ⟶ U-239 ⟶ Np-239

Chemical analysis of the debris shows that in general about one neutron is captured in this way for every fission that occurs, both in nominal bombs and in thermonuclear explosions. The U^{239} decays completely before reaching the U.K. but at four days after time of burst the Np^{239} disintegration rate reaches a peak relative to that of the fission products and accounts for about 60% of the observed activity at that time.

In addition to this, a smaller number of the neutrons in a thermonuclear explosion undergo an (n,2n) reaction with U^{238} to form 6.7 day U^{237} which is also a (β, γ) emitter.

neutron (high energy) + U-238 ⟶ 2 neutrons + U-237

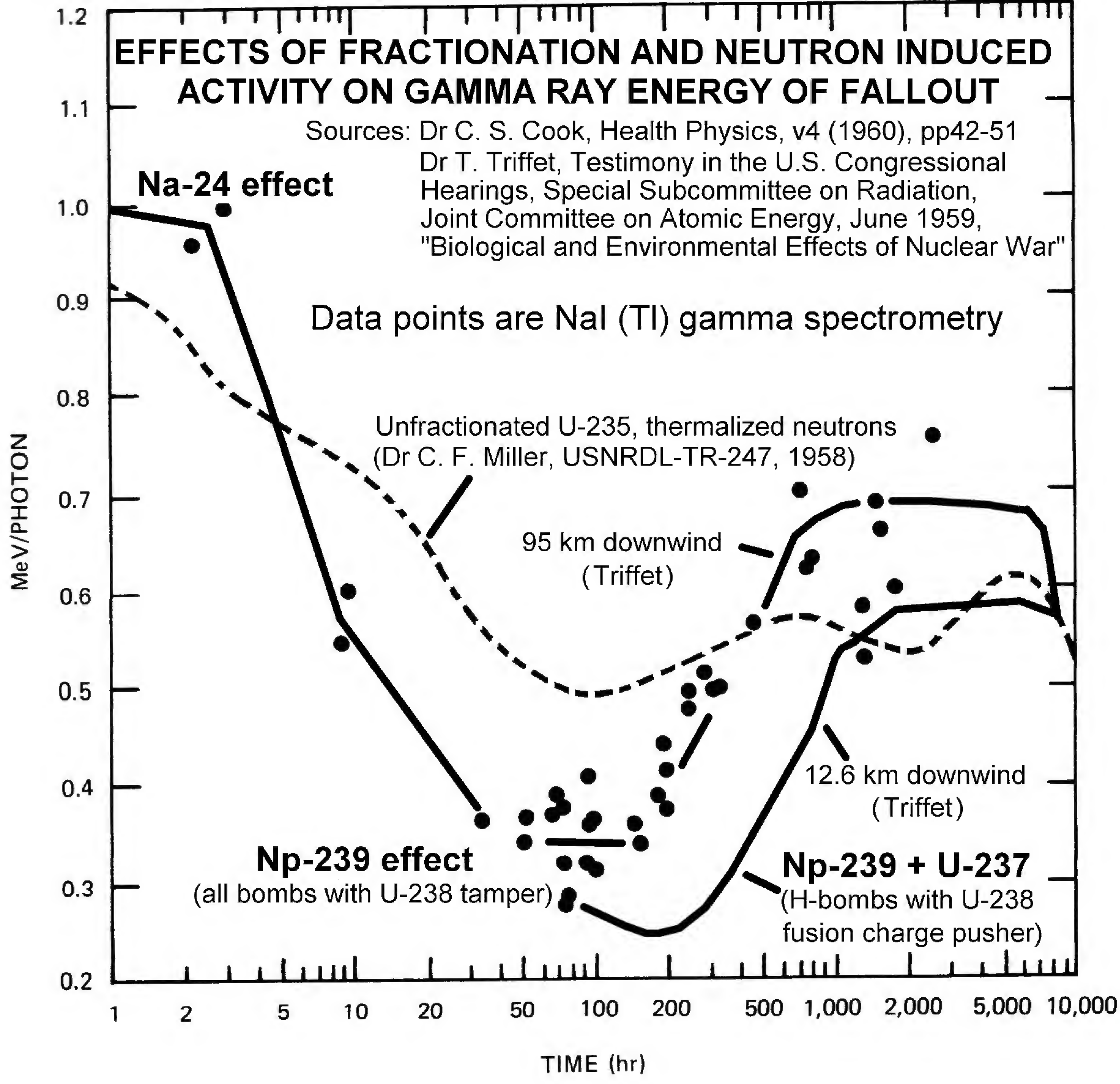


MEAN FALLOUT GAMMA ENERGY FOR LAND BURSTS ZUNI AND TEWA AND AIR BURST CHEROKEE

Terry Triffet and Philip D. LaRiviere, *Characterization of Fallout*, WT 1317 (1961), Table B.21

Test	Mt	Fission	Sample	2 days	3 days	4 days	7 days	10 days	14 days
Aircraft-collected unfractionated cloud samples (no depletion of volatile fission products):									
*Navajo**	4.50	5%	Cloud	0.57	0.48	0.45	0.44	0.53	0.60
Zuni	3.53	15%	Cloud	0.48	0.41	0.42	0.43	0.49	
Tewa	5.01	87%	Cloud		0.40	0.38	0.37	0.46	0.49
*Flathead**	0.365	73%	Cloud			0.34			0.54
Cherokee	3.75	50%	Cloud	0.29	0.30	0.31	0.34	0.42	0.49
*Sea water burst fallout is similar to cloud sample (100 °C droplet condensation prevents fractionation).									
Deposited fractionated land surface burst close-in fallout samples (depletion of volatile fission products):									
Tewa	5.01	87%	YFNB13E56					0.27	0.30
Zuni	3.53	15%	How F-61					0.21	

- Laboratory instrument measurements (ignores degradation due to air scatter of gamma rays). The "clean bombs" *Navajo* and *Zuni* cloud samples include high-energy gamma from sodium-24 (15 hours half life) due to neutron capture by sea salt (NaCl). Low-energy gammas, from Np-239 and U-237 due to neutron capture in U-238, contribute a high proportion of fallout radiation at 4-14 days. Fractionation depletes volatile chains, not Np-239 and U-237, so the mean energy is reduced further.


EFFECTS OF FRACTIONATION AND NEUTRON INDUCED ACTIVITY ON GAMMA RAY ENERGY OF FALLOUT
Sources: Dr C. S. Cook, Health Physics, v4 (1960), pp42-51
Dr T. Triffet, Testimony in the U.S. Congressional Hearings, Special Subcommittee on Radiation, Joint Committee on Atomic Energy, June 1959, "Biological and Environmental Effects of Nuclear War"
Na-24 effect
Data points are NaI (TI) gamma spectrometry
Unfractionated U-235, thermalized neutrons (Dr C. F. Miller, USNRDL-TR-247, 1958)
95 km downwind (Triffet)
12.6 km downwind (Triffet)
Np-239 effect
(all bombs with U-238 tamper)
Np-239 + U-237
(H-bombs with U-238 fusion charge pusher)
MeV/PHOTON
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
TIME (hr)
1
2
5
10
20
50
100
200
500
1,000
2,000
5,000
10,000

Zuni* fallout gamma ray spectrum measured at 10 days after detonation, 13 miles downwind (sample How F-61 GA)

Gamma ray energy (MeV)	% of gamma rays emitted by fallout sample
0.060	15.5
0.105	38.8
0.220	19.4
0.280	9.3
0.330	3.8
0.500	3.9
0.650	3.1
0.750	6.2
Mean energy	**0.218 MeV**

*W. E. Thompson, *Spectrometric Analysis of Gamma Radiation from Fallout from Operation Redwing,* U. S. Naval Radiological Defense Laboratory technical report USNRDL-TR-146, 29 April 1957, Tables 1 and 2. Note that this is the gamma ray spectrum actually measured for a fallout sample placed near the scintillation crystal of a gamma ray spectrometer, so it does not include the further reduction in gamma ray energy that occurs from Compton scattering in the atmosphere.

BIOLOGICAL AND ENVIRONMENTAL EFFECTS OF NUCLEAR WAR

HEARINGS

BEFORE THE

SPECIAL SUBCOMMITTEE ON RADIATION

OF THE

JOINT COMMITTEE ON ATOMIC ENERGY CONGRESS OF THE UNITED STATES

EIGHTY-SIXTH CONGRESS

FIRST SESSION

ON

BIOLOGICAL AND ENVIRONMENTAL EFFECTS OF NUCLEAR WAR

JUNE 22, 23, 24, 25, AND 26, 1959

PART 1

Printed for the use of the Joint Committee on Atomic Energy

UNITED STATES
GOVERNMENT PRINTING OFFICE
43338 WASHINGTON : 1959

RADIATION CHARACTERISTICS OF LAND SURFACE BURST FALLOUT

	8 mi downwind	60 mi downwind
Average γ Energy		
1 hr	--	1.0 mev
2 hr	--	0.95
1/2 day	--	0.60
1 day	--	0.40
1 week	0.25 mev	0.35
1 mo	0.45	0.65

RADIATION CHARACTERISTICS OF WATER SURFACE BURST FALLOUT

	7 mi downwind	22 mi downwind
Average γ Energy		
1 hr		1.0 mev
2 hr		0.95
1/2 day		0.60
1 day		0.40
1 week		0.35
1 mo		0.65

MYRON HAWKINS:

the induced radiation in uranium 238. We can refer to a British report which indicates that around 60 percent of the total activity at 4 days—activity in this case is the number of disintegrations—is due to the uranium 239 and neptunium 239 that are produced, as the British say, in either large or small weapons. I believe part of the hump on the curves in the early times, say around 4 days, is largely due to this.

Dr. TRIFFET. Yes. I thought this might be an appropriate place to comment on the variation of the average energy. It is clear when you think of shielding, because the effectiveness of shielding depends directly on the average energy radiation from the deposited material. As I mentioned, Dr. Cook at our laboratory has done quite a bit of work on this. What it amounts to is that at one hour the average energy is about one Mev. This appears, by the way, in the tables that are in my written statement but that I did not present orally.

Representative HOLIFIELD. Mev. means?

Dr. TRIFFET. Million electron volts. At 2 hours it drops to 0.95. At a half day, to 0.6. At 1 week it drops to 0.35. Then it begins to go up again. At 1 month, it is 0.65, 2 months 0.65. The meaning of this is simply that there is a period around 1 week when if induced products are important in the bomb, there are a lot of radiations emanating from these, but the energy is low so it operates to reduce the average energy in this period and shielding is immensely more effective.

Strontium 90, for example, has 33-second krypton as its birth predecessor; cesium 137 derives from a fission chain headed up by 22-second iodine, followed by 3.9-minute xenon. Because of their volatile or gaseous ancestry in the fireball or bomb cloud a number of the high-yield fission products are formed in finely divided particles. Some of these are so small that they are not subject to gravitational settling, and in fact they remain suspended in the earth's atmosphere for many years, providing[6] that they reach the stratosphere at the proper latitude. In any event such fission products would be depleted in the local fallout.

For example, the irradiation of uranium^{238} with low Mev. neutrons forms neptunium 239, a 2.3-day radioelement which W. J. Heiman[7] estimates might constitute 50 percent of the residual activity a few days after a bomb detonation.

At higher neutron energies, such as certain types of thermonuclear weapons produce, natural uranium undergoes an (n,2n) reaction which competes with fast fission in U^{238}. The data of R. J. Howerton[8] show that U^{238} has a fission cross section of 0.6 barn from 2 to 6 Mev., thereafter climbing to a plateau value of 1 barn for neutrons up to 14 Mev. At 6.6 Mev. there is a threshold for the (n,2n) reaction and the reaction has a cross section of 1.4 barns in the range of 10 Mev. The ready identification of U^{237} in fallout points to fast fission of U^{238} as a main energy source in high-yield megaton-class weapons.

[6] See E. A. Martell, "Atmospheric Circulation and Deposition of Strontium 90 Debris," Air Force Cambridge Research Center paper (July 1958). See also W. F. Libby, "Radioactive Fallout," speech of Mar. 13, 1959.

[7] Variation of Gamma Radiation Rates for Different Elements Following an Underwater Nuclear Detonation," J. Colloid. Science, 13 (1958), p. 329.

[8] "Reaction Cross Sections of U^{238} in the Low Mev. Range," UCRL 5323 (Aug. 15, 1958).

WT-1316 (EX)
EXTRACTED VERSION

OPERATION REDWING

Project 2.62a
Fallout Studies by Oceanographic Methods

Pacific Proving Grounds

May - July, 1956

Defense Atomic Support Agency

Sandia Base, Albuquerque, New Mexico

February 6, 1961

NOTICE

This is an extract of **WT-1316, Operation REDWING, Project 2.62a**, which remains classified **Secret/ Restricted Data** as of this date.

Extract version prepared for:

Director
DEFENSE NUCLEAR AGENCY
Washington, D.C. 20305

1 February 1980

CLEAN BOMB: 3.53 MT (15% FISSION) ZUNI

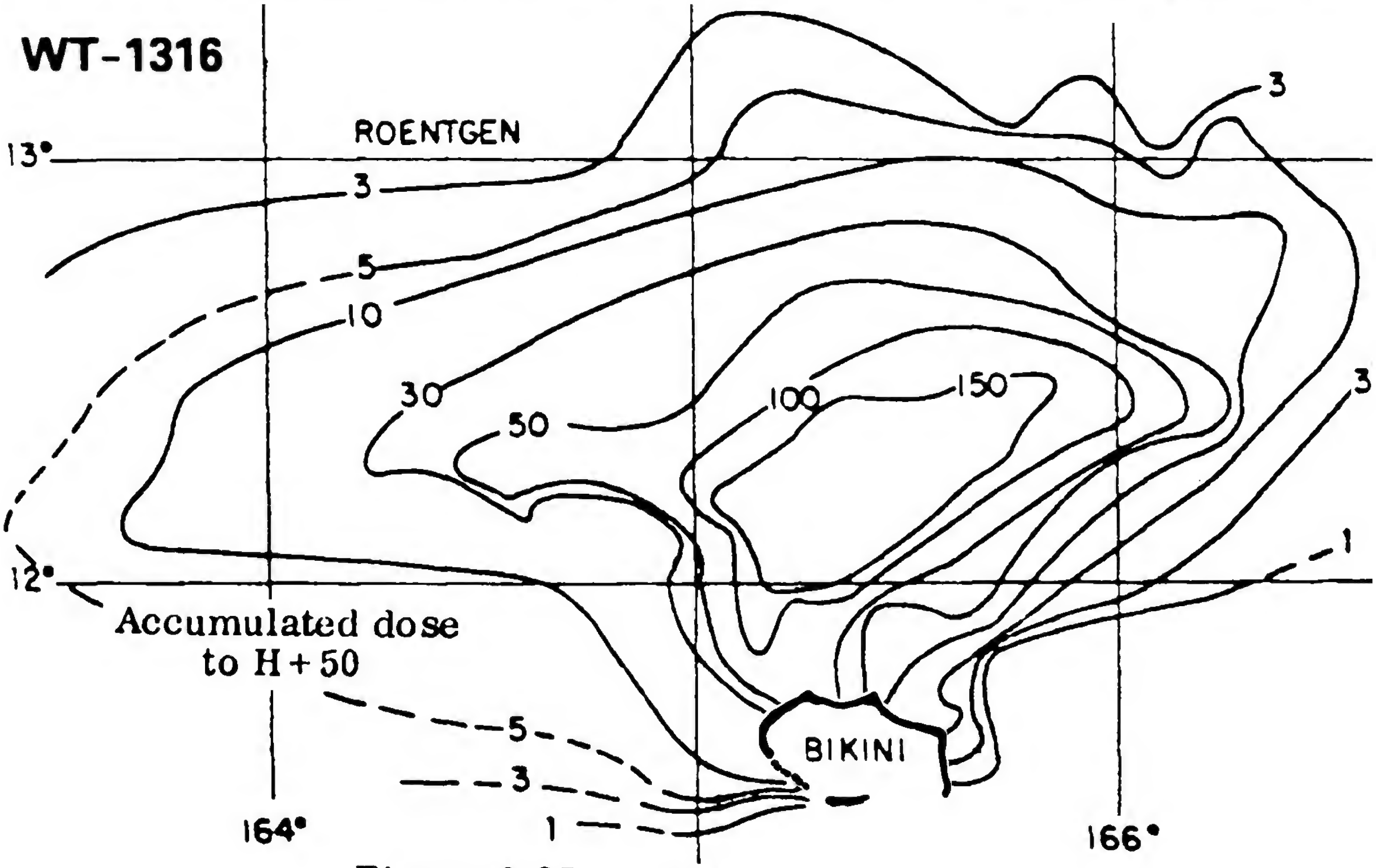


Figure 2.37

DIRTY BOMB: 5.01 MT (87% FISSION) TEWA

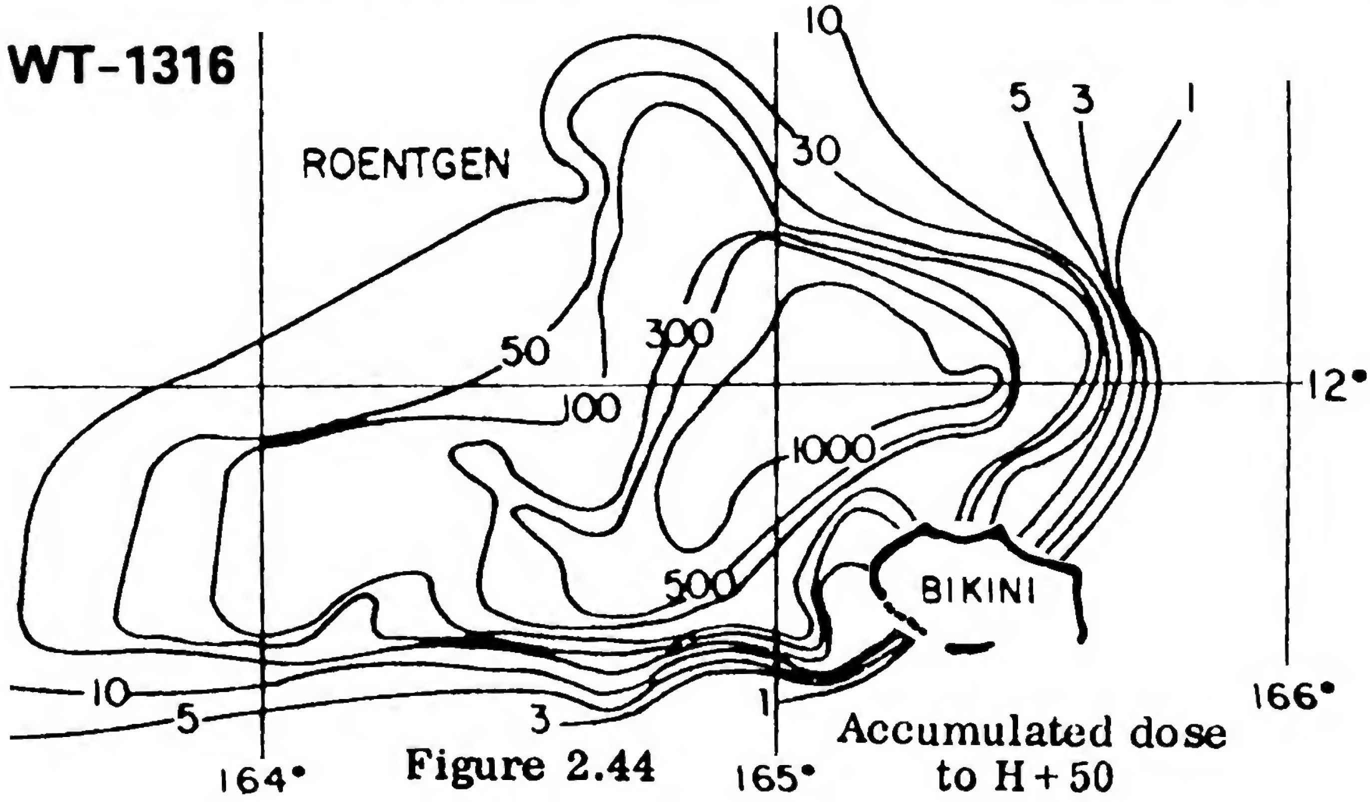


Figure 2.44

TABLE 2.11

	Navajo	Tewa
Total Yield, Mt	4.50	5.01
Fission proportion	5%	87%
H + 1 Hour Dose Rate (r/hr)	**Area (mi^2) Within Contour**	
1,000	25	450
500	55	1,050
300	80	1,550
100	310	3,500
Two-day Dose, R	**Area (mi^2) Within Contour**	
1,000	20	520
500	30	1,050
300	45	1,500
100	350	3,000

AD-A995490

POR-2266 (WT-2266)

TABLE 4.1

AREAS ENCLOSED BY DOSE RATE CONTOURS

	0.018 kt	0.022 kt	0.5 kt	1.65 kt
Contour Dose Rate, I	Area Within Contour			
	Little Feller I	Little Feller II	Johnie Boy	Small Boy
r/hr	mi^2	mi^2	mi^2	mi^2
0.5	0.33	0.827	-	109.83
1.0	0.208	0.469	33.097	61.63
5.0	-	0.070	-	-
10.0	0.032	0.045	3.924	9.057
20.0	-	0.019	-	-
50.0	-	-	0.536	2.954
100.0	0.00478	0.005	0.214	1.200
200.0	-	-	-	0.285
1,000.0	-	-	0.0917	0.092
2,000.0	-	-	-	0.01665
10,000.0	-	-	0.0161	-
17,000.0	-	-	0.00537	-

PRIME MINISTER

Clandestine Use of Atomic Weapons

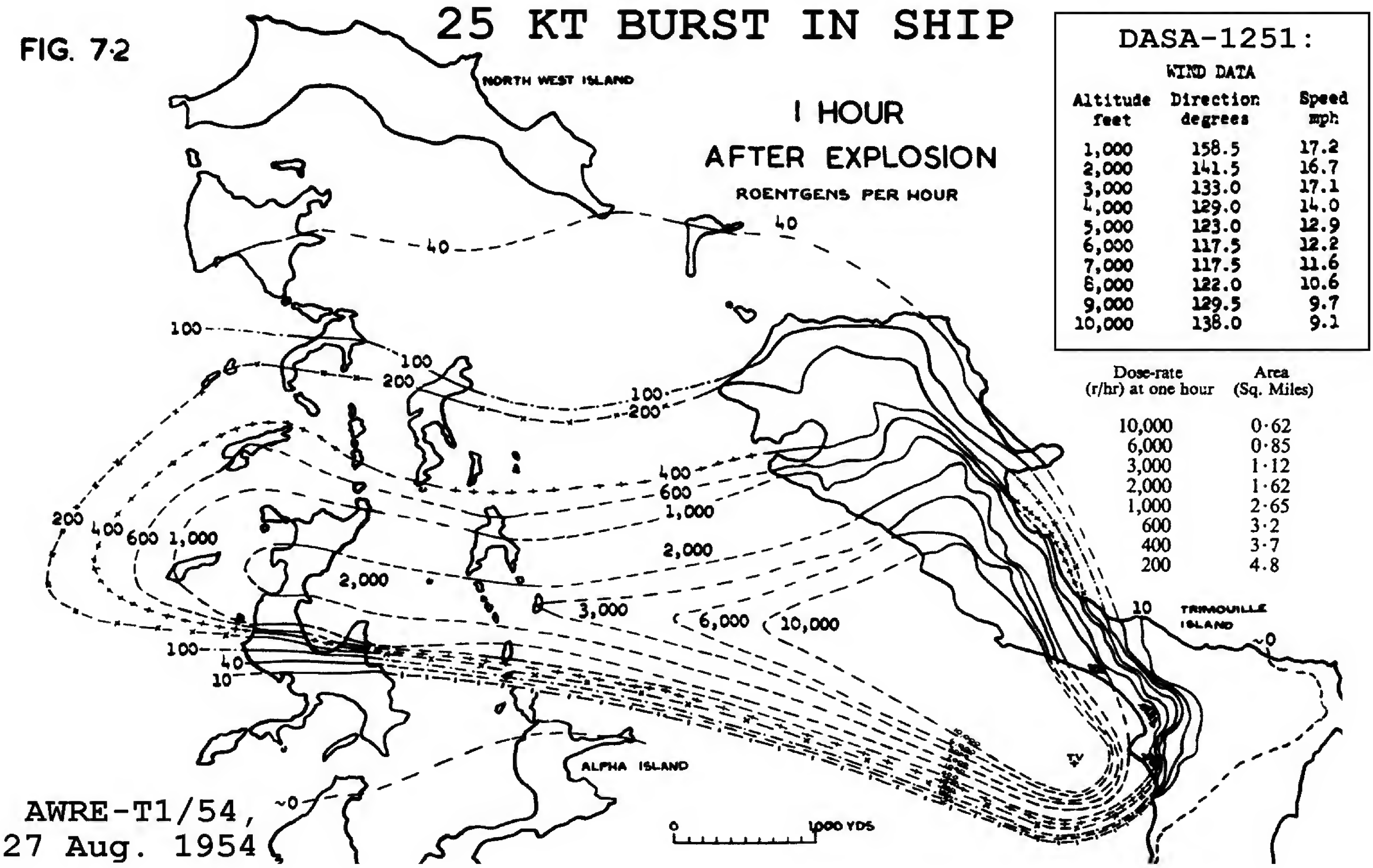
The Chiefs of Staff have been considering the possibility that the enemy might open the next war with an atomic attack on London on the model of the Japanese attack on Pearl Harbour - without warning and before any formal declaration of hostilities. The most effective method of making such an attack would be to drop an atomic bomb from a military aircraft. If the control and reporting system were fully manned and alert in a period of tension, there would be some chance that hostile aircraft approaching this country could be intercepted and driven off. At any rate, there are no special measures, outside the normal measures of air defence, which we could take in peace-time to guard against this type of attack.

2. It is, however, possible that the enemy might use other means of surprise attack with atomic weapons. A clandestine attack could be made in either of the following ways:-

(i) A complete atomic bomb could be concealed in the hold of a merchant ship coming from the Soviet Union or a satellite country to a port in the United Kingdom:

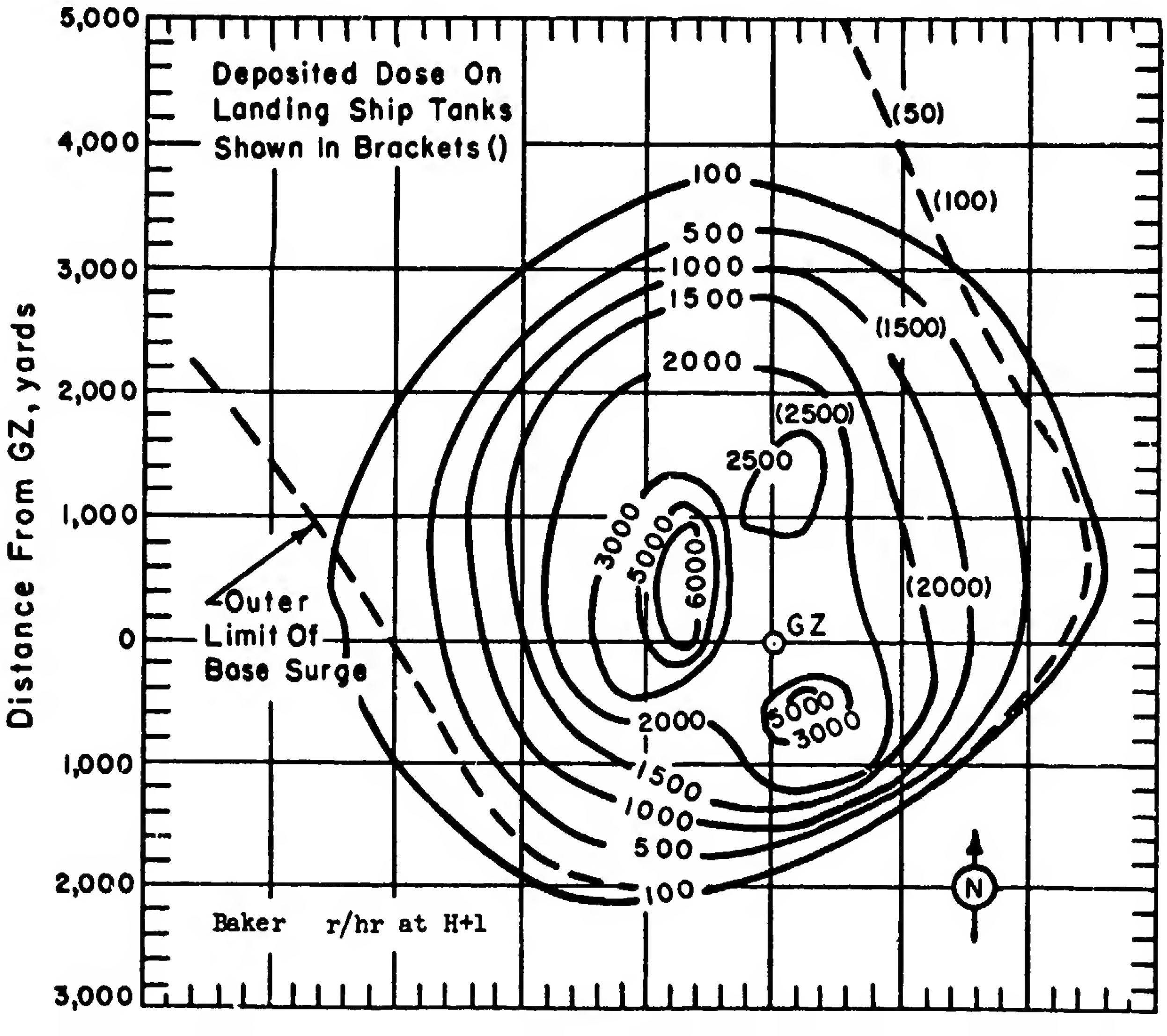
(ii) An atomic bomb might be broken down into a number of parts and introduced into this country in about fifty small packages of moderate weight. None of these packages could be detected by instruments as containing anything dangerous or explosive, and even visual inspection of the contents of the packages would not make identification certain. These packages could be introduced either as ordinary merchandise from Soviet ships, or possibly as diplomatic freight. The bomb could subsequently be assembled in any premises with the sort of equipment usual in a small garage, provided that a small team of skilled fitters was available to do the job.

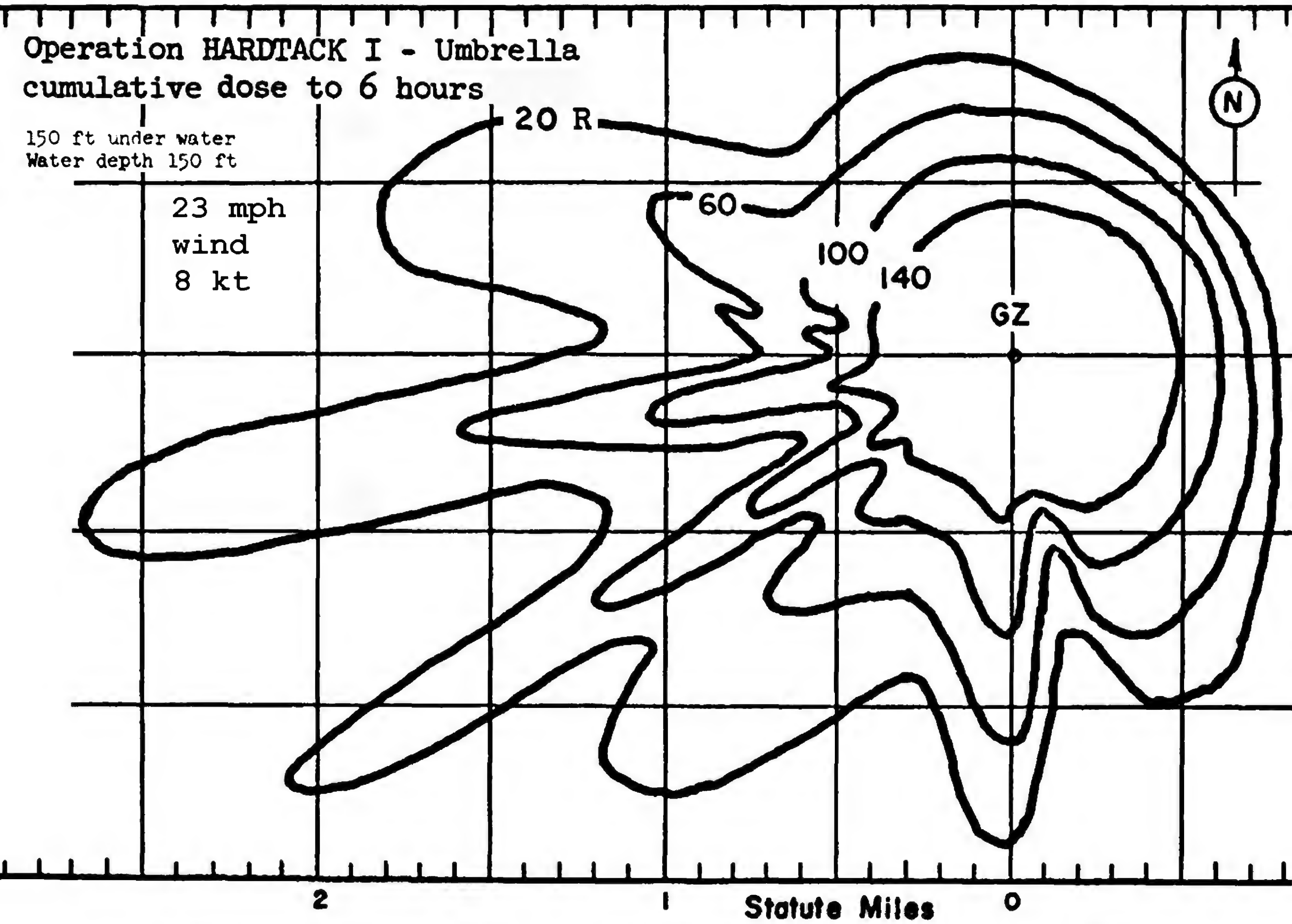
OPERATION HURRICANE—THE DOSE-RATE CONTOURS OF THE RESIDUAL RADIOACTIVE CONTAMINATION

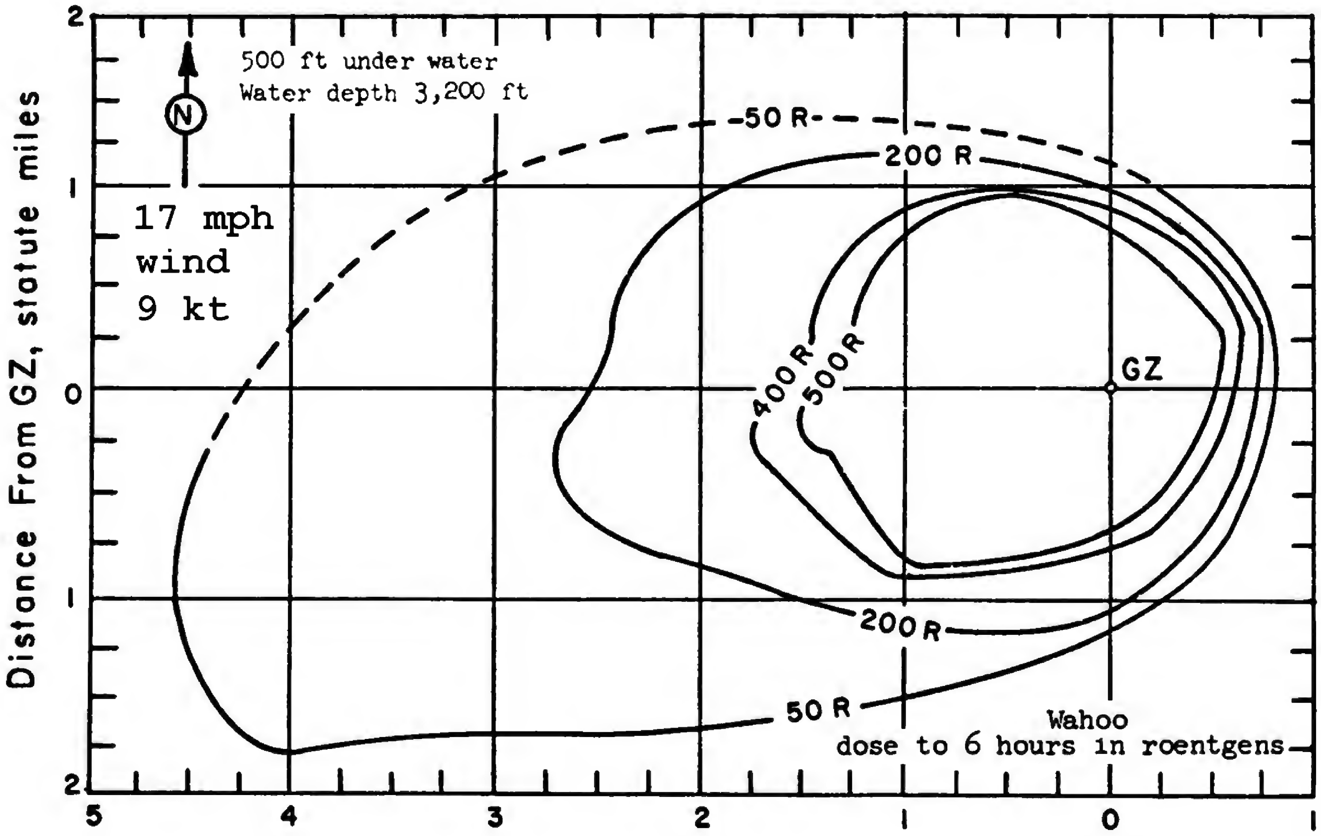


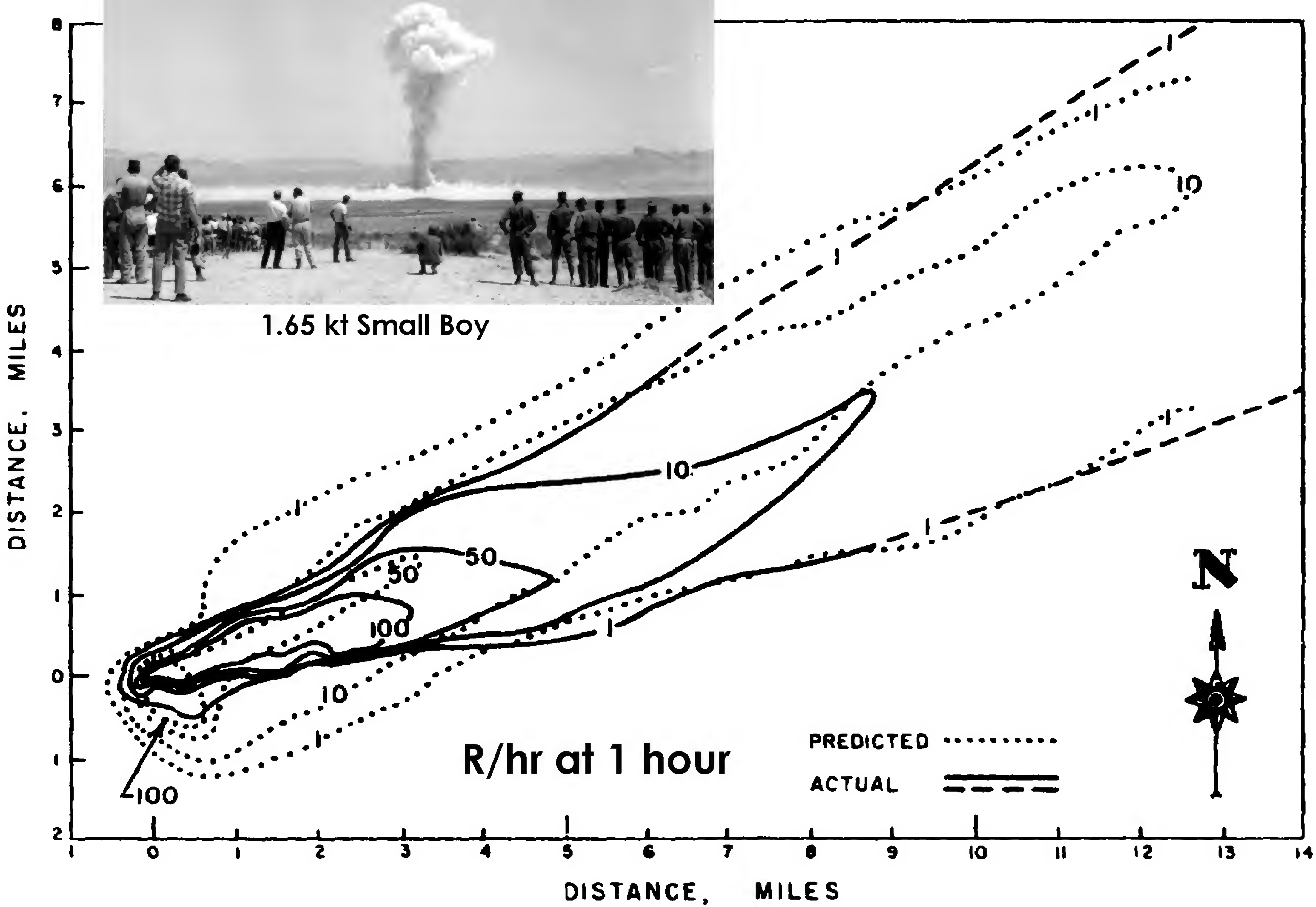
Altitude feet	Direction degrees	Speed mph
1,000	158.5	17.2
2,000	141.5	16.7
3,000	133.0	17.1
4,000	129.0	14.0
5,000	123.0	12.9
6,000	117.5	12.2
7,000	117.5	11.6
8,000	122.0	10.6
9,000	129.5	9.7
10,000	138.0	9.1

Dose-rate (r/hr) at one hour	Area (Sq. Miles)
10,000	0·62
6,000	0·85
3,000	1·12
2,000	1·62
1,000	2·65
600	3·2
400	3·7
200	4·8



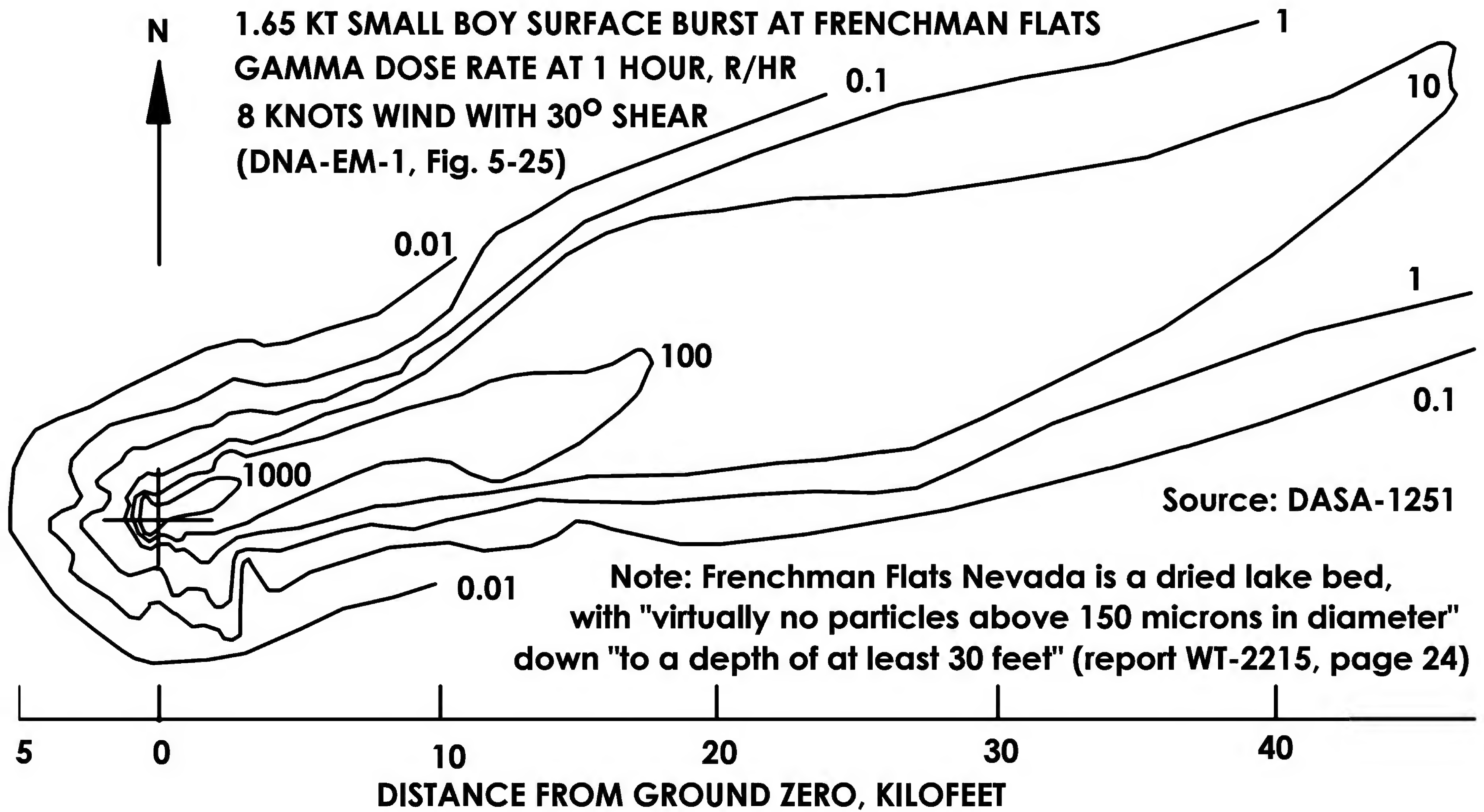

Operation HARDTACK I - Umbrella
cumulative dose to 6 hours
150 ft under water
Water depth 150 ft
23 mph
wind
8 kt
N
20 R
60
100
140
GZ
2
1
Statute Miles
0

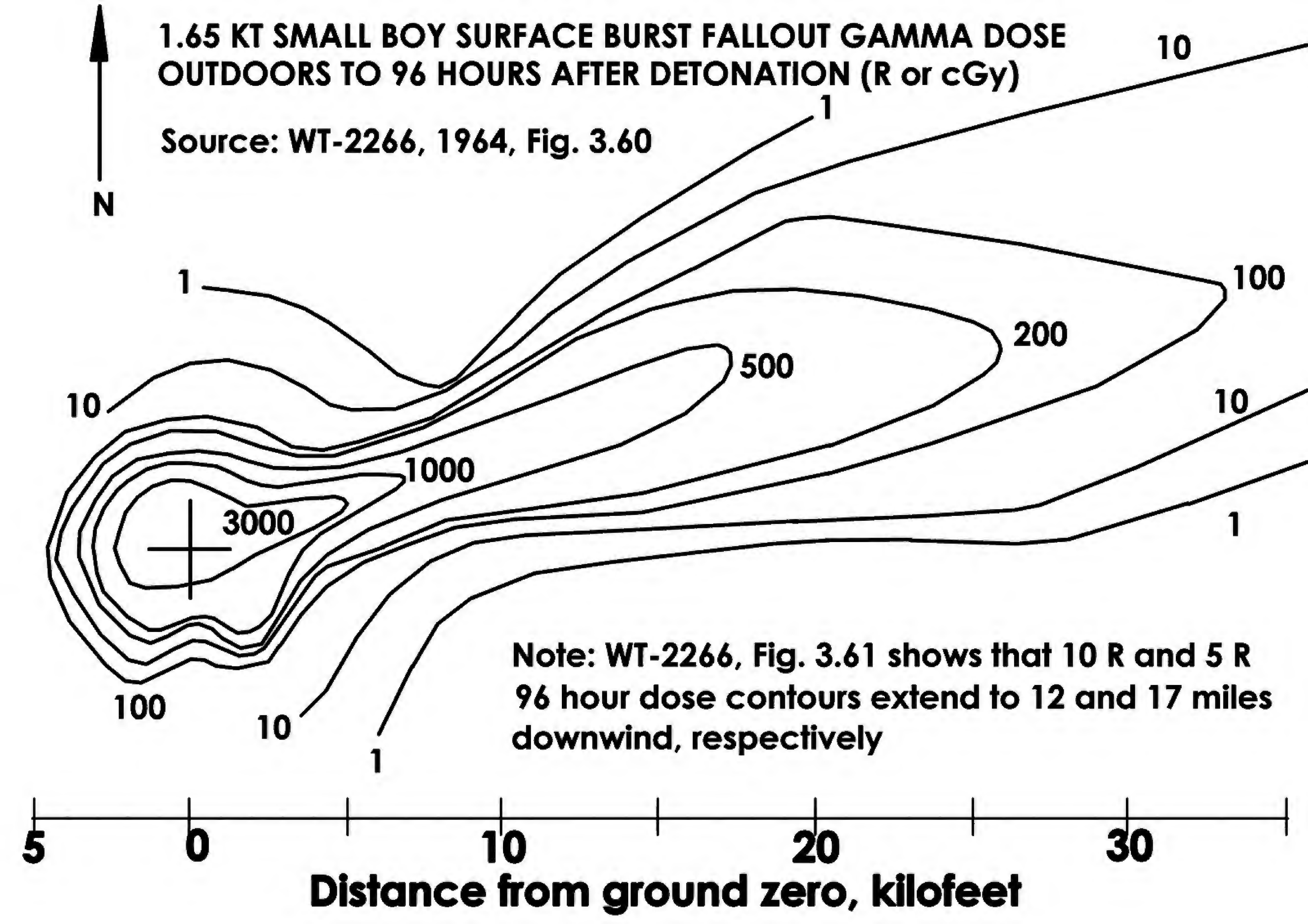

500 ft under water
Water depth 3,200 ft
N
17 mph
wind
9 kt
50 R
200 R
400 R
500 R
GZ
200 R
50 R
Wahoo
dose to 6 hours in roentgens
Distance From GZ, statute miles
2
1
0
1
2
5
4
3
2
1
0
1

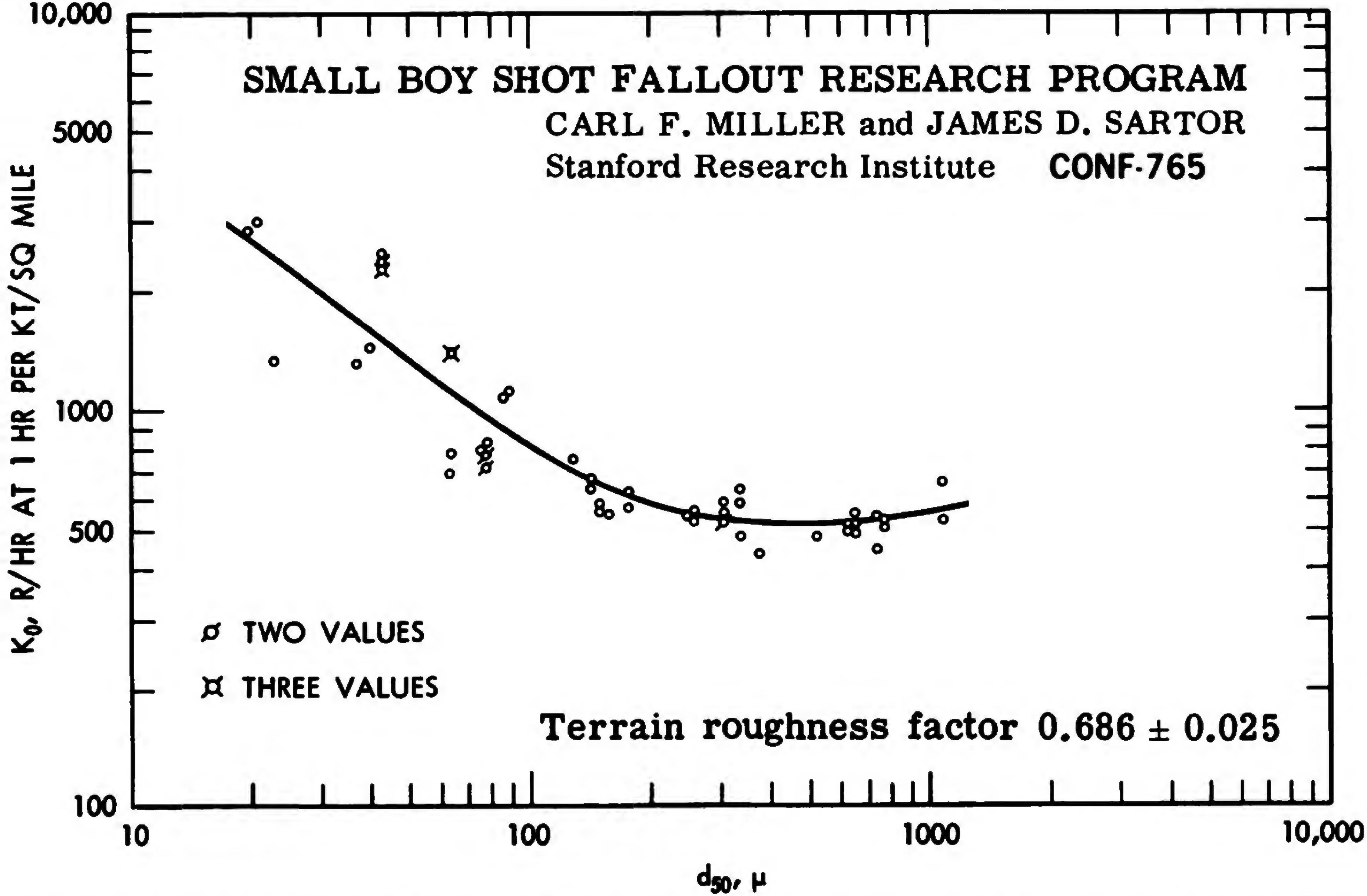


AD–A995490
POR-2266 (WT-2266)

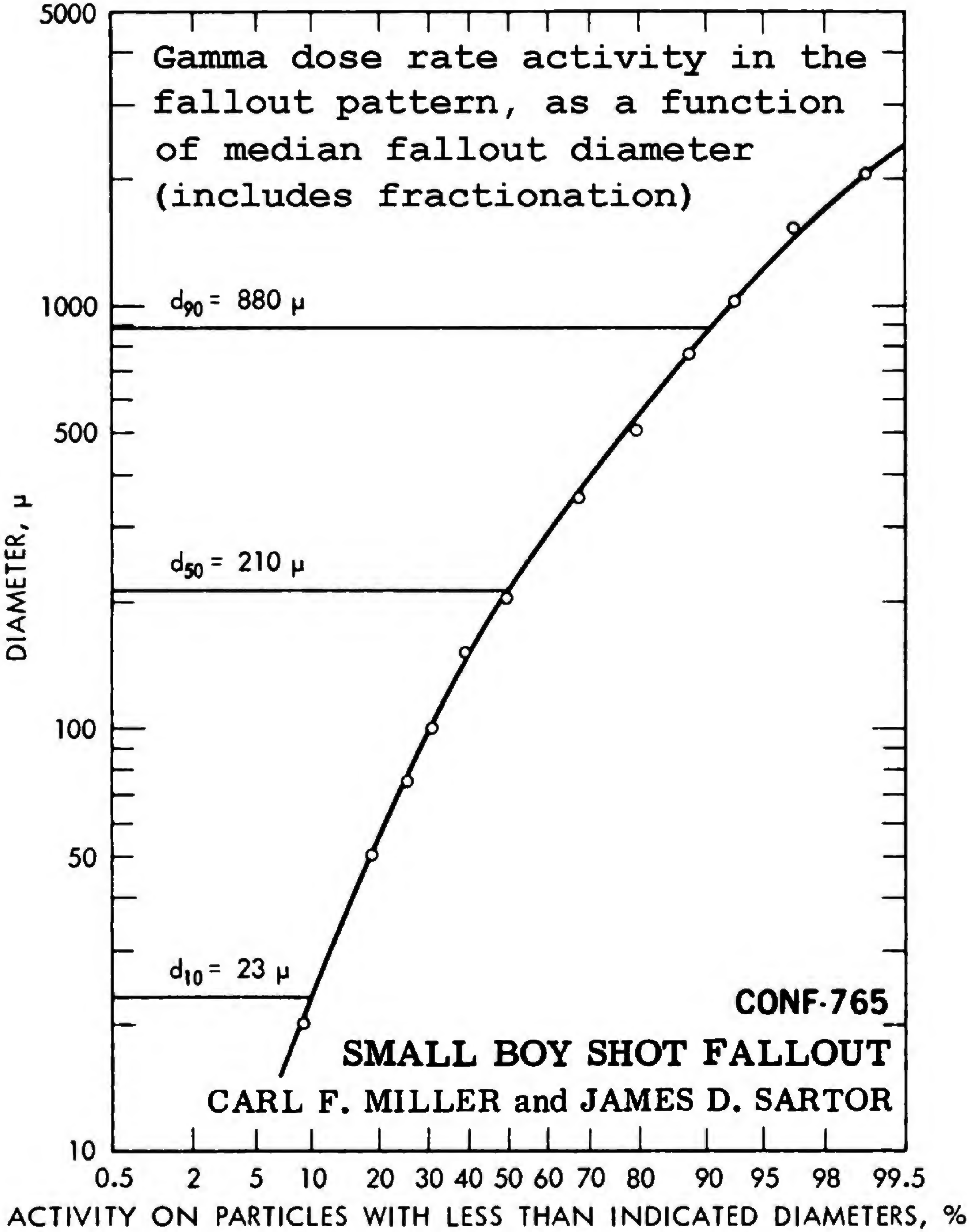
Figure 4.13 Comparison of Ford Instrument Company prediction with observed Small Boy pattern.


N
1.65 KT SMALL BOY SURFACE BURST AT FRENCHMAN FLATS
GAMMA DOSE RATE AT 1 HOUR, R/HR
8 KNOTS WIND WITH 30° SHEAR
(DNA-EM-1, Fig. 5-25)
1
0.1
10
0.01
1
100
0.1
1000
Source: DASA-1251
0.01
Note: Frenchman Flats Nevada is a dried lake bed,
with "virtually no particles above 150 microns in diameter"
down "to a depth of at least 30 feet" (report WT-2215, page 24)
5
0
10
20
30
40
DISTANCE FROM GROUND ZERO, KILOFEET


1.65 KT SMALL BOY SURFACE BURST FALLOUT GAMMA DOSE OUTDOORS TO 96 HOURS AFTER DETONATION (R or cGy)
Source: WT-2266, 1964, Fig. 3.60
N
1
10
100
200
500
1000
3000
Note: WT-2266, Fig. 3.61 shows that 10 R and 5 R 96 hour dose contours extend to 12 and 17 miles downwind, respectively
5
0
10
20
30
Distance from ground zero, kilofeet



Fractionation effect (factor including terrain shielding)



5000
1000
500
100
50
10
DIAMETER, μ
Gamma dose rate activity in the fallout pattern, as a function of median fallout diameter (includes fractionation)
d90 = 880 μ
d50 = 210 μ
d10 = 23 μ
CONF-765
SMALL BOY SHOT FALLOUT
CARL F. MILLER and JAMES D. SARTOR
0.5
2
5
10
20
30
40
50
60
70
80
90
95
98
99.5
ACTIVITY ON PARTICLES WITH LESS THAN INDICATED DIAMETERS, %

CONF-765

EARLY FOOD-CHAIN KINETICS OF RADIONUCLIDES FOLLOWING CLOSE-IN FALLOUT FROM A SINGLE NUCLEAR DETONATION

WILLIAM E. MARTIN
University of California at Los Angeles, Los Angeles, California

ABSTRACT

Radiochemical and statistical analyses indicated highly significant correlations between estimates of gamma dose rates and maximum concentrations of ^{89}Sr or ^{131}I in plant samples and in the stomach contents, bone ash, or thyroids of rabbits collected between 15 and 110 miles from ground zero.

Table 1 — AVERAGE GAMMA DOSE RATES, R_0, AND AVERAGE CONCENTRATIONS OF ^{89}Sr IN PLANT SAMPLES AND IN THE BONE ASH OF RABBITS COLLECTED FROM THE SEDAN FALLOUT FIELD

Study areas	Initial gamma dose rates $\bar{x}$	$s\bar{x}$	n	Days after detonation	Plant samples, pc ^{89}Sr/g (dry) $\bar{x}$	$s\bar{x}$	n	Rabbit bone ash, pc ^{89}Sr/g (dry) $\bar{x}$	$s\bar{x}$	n
				5	1436	±32%	20	863	±29%	20
All areas	17.5	±30%	20	15	909	±37%	20	1680	±38%	20
R_0 = mr/hr at 3 ft at H + 24.				30	544	±40%	20	2097	±30%	20
				60	313	±32%	20	1389	±34%	20

$\bar{x}$ = mean, $s\bar{x}$ = standard error expressed as a percentage of the mean, and n = number of samples.

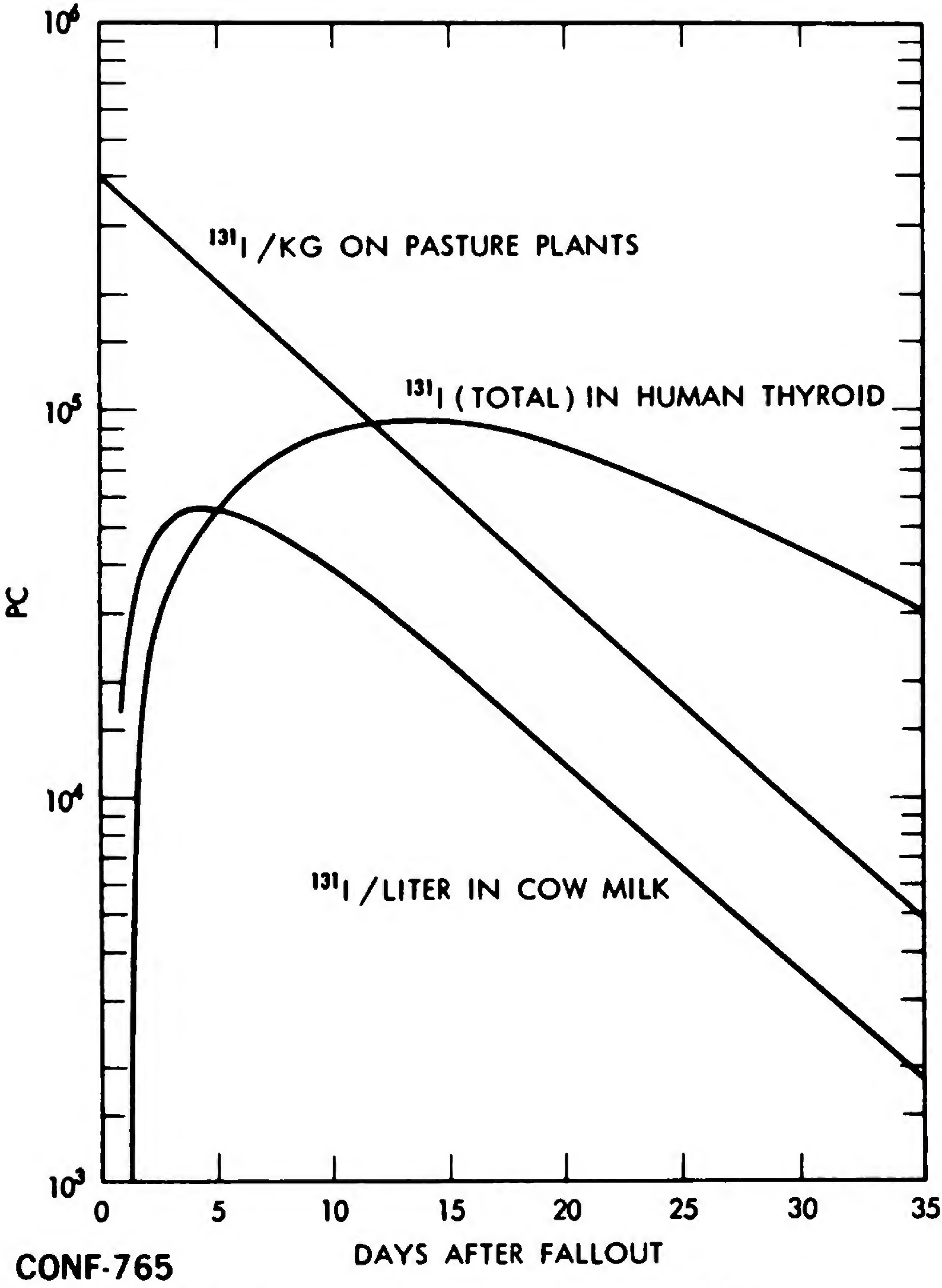
Table 2 — AVERAGE CONCENTRATIONS OF ^{131}I IN PLANT SAMPLES AND IN THE THYROIDS OF RABBITS COLLECTED FROM THE SEDAN FALLOUT FIELD

Study areas	Days after detonation	Plant samples, pc ^{131}I/g (dry) $\bar{x}$	$s\bar{x}$	n	Rabbit thyroids, nc ^{131}I per thyroid $\bar{x}$	$s\bar{x}$	n
All areas	5	3606	±40%	20	221	±28%	19
	15	984	±40%	20	74	±36%	20
	30	113	±27%	20	12	±50%	20

$\bar{x}$ = mean, $s\bar{x}$ = standard error expressed as a percentage of the mean, and n = number of samples.

Our estimates of effective half-lives on plants in the Sedan fallout field, 18 days for ^{89}Sr and 5.0 to 5.5 days for ^{131}I, indicate environmental half-lives (i.e., half-time rates of loss due to all causes other than radioactive decay) of approximately 28 days for ^{89}Sr and 15 days for ^{131}I. Since there was little or no rain in the area of the Sedan fallout field during the period of this study, the environmental half-life of ^{89}Sr on plants can be attributed primarily to wind action that removed particles from foliage or foliage from plants. The shorter environmental half-life of ^{131}I on plants may reflect the combined effects of wind action and sublimation.[1,2]

1. W. E. Martin, Losses of Sr^{90}, Sr^{89}, and I^{131} from Fallout Contaminated Plants, *Radiation Botany*, in press.
2. W. E. Martin, Loss of I^{131} from Fallout-contaminated Vegetation, *Health Phys.*, *9*: 1141-1148 (1963).

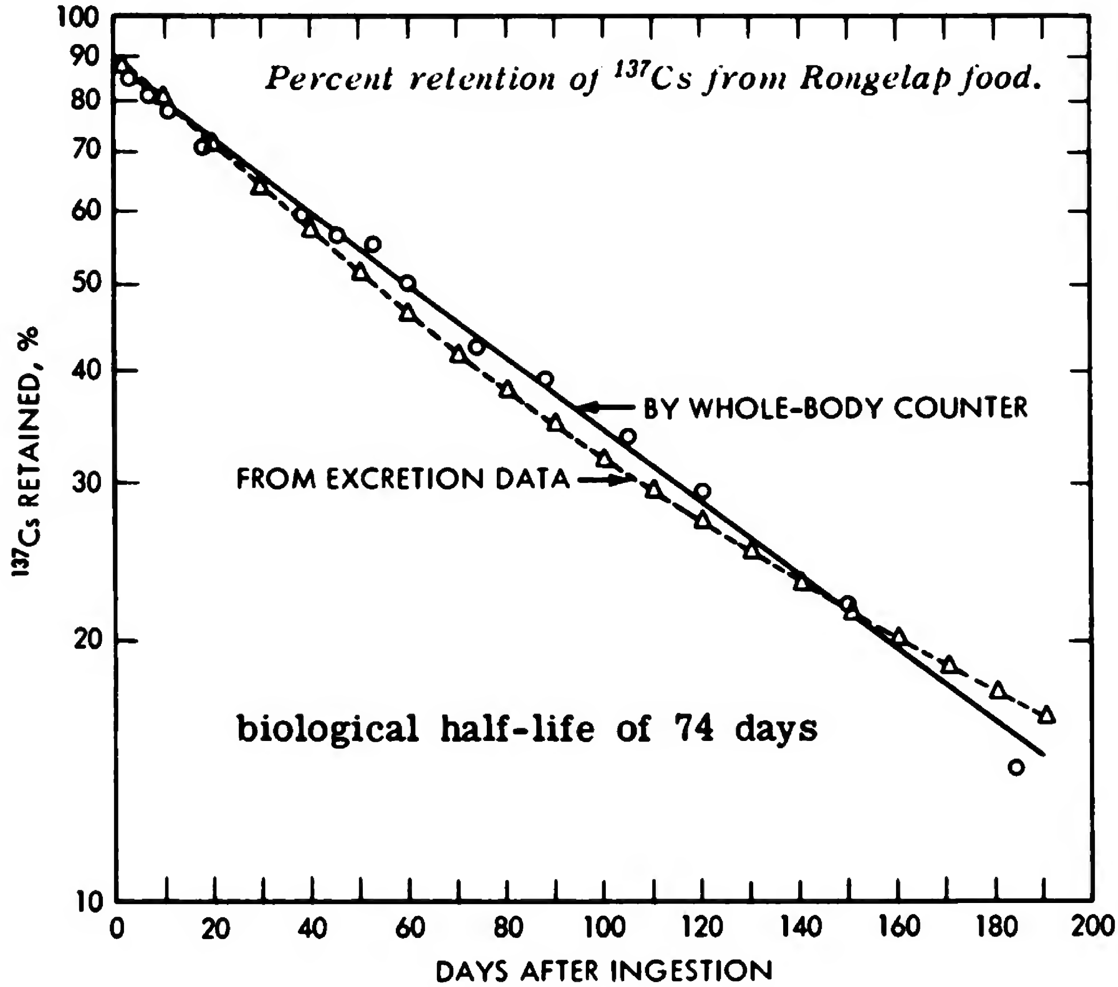


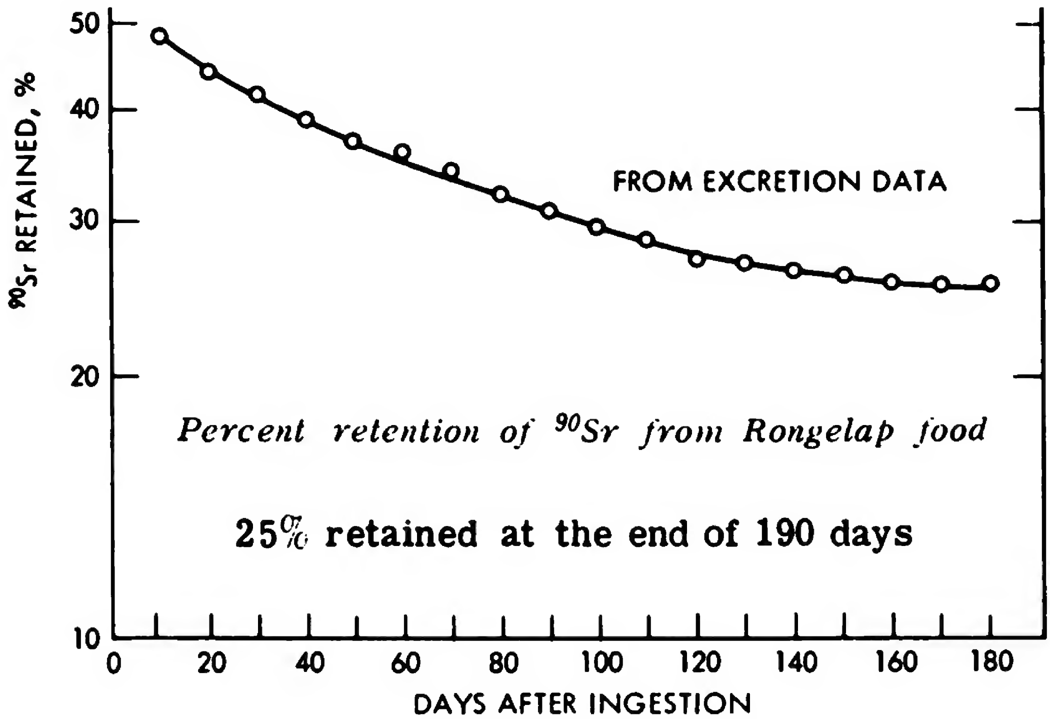
CONF-765

Fig. 8—Hypothetical concentrations of ^{131}I on pasture plants, in cow milk, and in human thyroids following environmental contamination by a single fallout event.

CESIUM-137 AND STRONTIUM-90 RETENTION FOLLOWING AN ACUTE INGESTION OF RONGELAP FOOD

EDWARD P. HARDY, Jr.,* JOSEPH RIVERA,* and ROBERT A. CONARD†
*Health and Safety Laboratory, U. S. Atomic Energy Commission, New York, New York, and †Brookhaven National Laboratory, Upton, New York.





Survival of Food Crops and Livestock in the Event of Nuclear War

Proceedings of a symposium held at
Brookhaven National Laboratory
Upton, Long Island, New York
September 15–18, 1970

Sponsored by
Office of Civil Defense
U. S. Atomic Energy Commission
U. S. Department of Agriculture

Editors

David W. Bensen
Office of Civil Defense
Arnold H. Sparrow
Brookhaven National Laboratory

December 1971

U. S. ATOMIC ENERGY COMMISSION Office of Information Services

THE SIGNIFICANCE OF LONG-LIVED NUCLIDES AFTER A NUCLEAR WAR

R. SCOTT RUSSELL, B. O. BARTLETT, and R. S. BRUCE
Agricultural Research Council, Letcombe Laboratory, Wantage, Berkshire, England

ABSTRACT

The radiation doses from the long-lived nuclides ^{90}Sr and ^{137}Cs, to which the surviving population might be exposed after a nuclear war, are considered using a new evaluation of the transfer of ^{90}Sr into food chains.

As an example, it is estimated that, in an area where the initial deposit of near-in fallout delivered 100 R/hr at 1 hr and there was subsequent worldwide fallout from 5000 Mt of fission, the dose commitment would be about 2 rads to the bone marrow of the population and 1 rad to the whole body. Worldwide fallout would be responsible for the major part of these doses.

In view of the possible magnitude of the doses from long-lived nuclides, the small degree of protection that could be provided against them, and the considerable strain any such attempt would impose on the resources of the community, it seems unrealistic to consider remedial measures against doses of this magnitude. Civil-defense measures should be directed at mitigating the considerably higher doses that short-lived nuclides would cause in the early period.

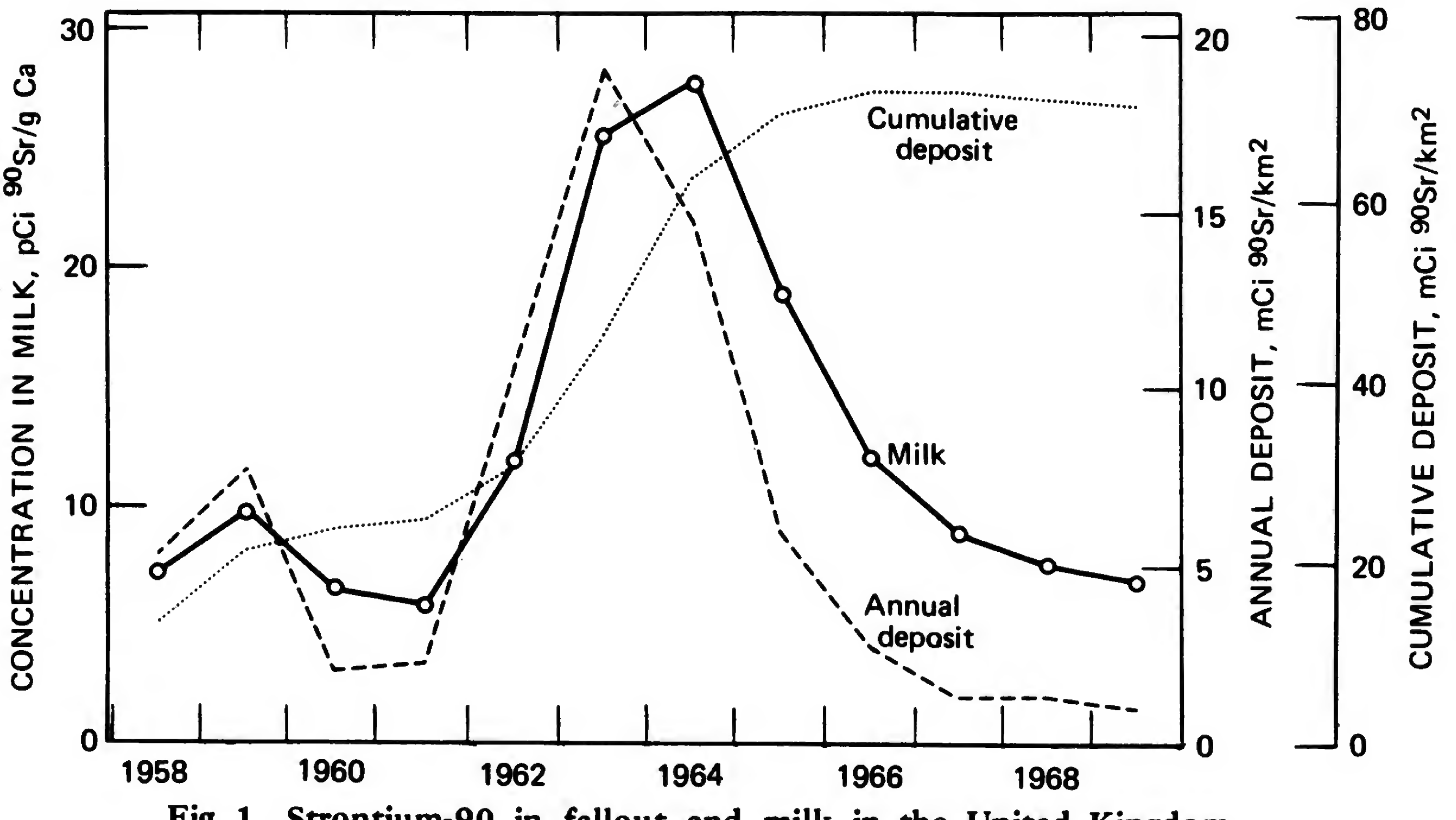


Fig. 1 Strontium-90 in fallout and milk in the United Kingdom

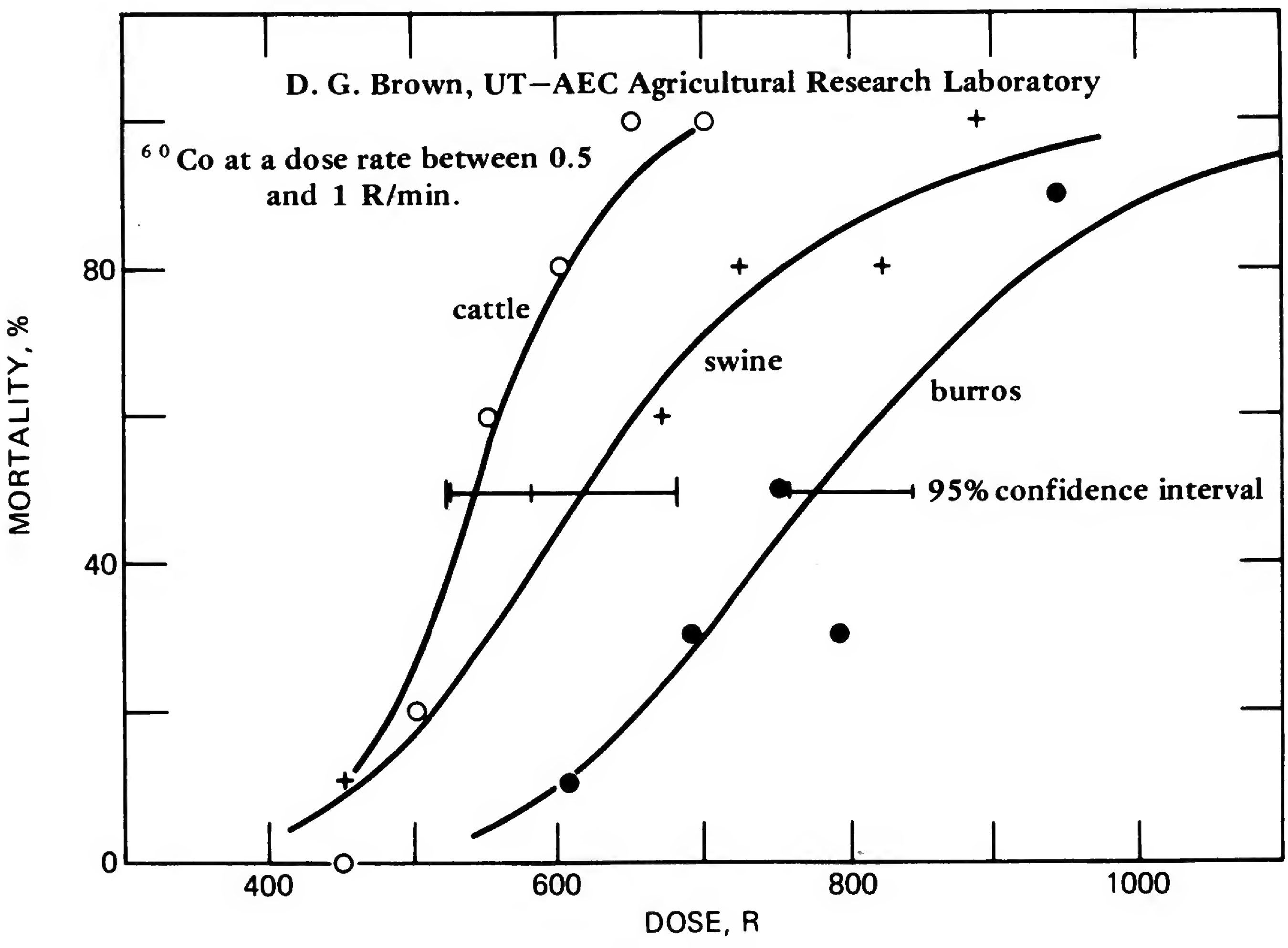
RADIATION EFFECTS ON FARM ANIMALS: A REVIEW

M. C. BELL
UT–AEC Agricultural Research Laboratory, Oak Ridge, Tennessee

ABSTRACT

Hematopoietic death would predominate in food-producing animals exposed to gamma radiation under fallout conditions leaving animal survivors. Gamma-radiation doses of about 900 R would be lethal to 50% of poultry, and about half this level would be lethal for cattle, sheep, and swine. Grazing cattle and sheep would suffer most from combined radiation effects of skin-beta and ingested-beta radioactivity plus the whole-body gamma effects. The $LD_{50/60}$ for combined effects in ruminants is estimated to be at a gamma exposure of around 200 R in an area where the forage retention is 7 to 9%.

Either external parasites or severe heat loss could be a problem in skin irradiated animals. Contrary to early reports, bacterial invasion of irradiated food-producing animals does not appear to be a major problem. Productivity of survivors of gamma radiation alone would not be affected, but, in an area of some lethality, the productivity of surviving grazing livestock would be severely reduced owing to anorexia and diarrhea. Sheltering animals and using stored feed as countermeasures during the first few days of livestock exposure provide much greater protection than shielding alone.



Local Fallout from Nuclear Test Detonations (U), DASA 1251-series (5 volumes with 9 separately-bound parts), by U.S. Army Nuclear Defense Laboratory for the Defense Atomic Support Agency:

Volume I, Indexed Bibliography of United States and British Documents on Characteristics of Local Fallout (U), DASA 1251-1 (AD 329971), 237 pp., 27 June 1961. (C)

Volume II, Compilation of Fallout Patterns and Related Test Data (U):

Part 1 - Trinity Through Redwing (U), DNA 1251-2-1 (AD 349123), 468 pp., August 1963. (SRD)

Part 2 - Plumbbob Through Hardtack (U), DASA 1251-2-2 (AD 329124), 456 pp., August 1963. (SRD)

Part 3 - Nougat Through Niblic (U), DASA 1251-2-3 (AD 371725), 226 pp., March 1966. (SRD)

Supplement, Foreign Nuclear Tests (U), DASA 1251 (AD 358417L), 77 pp., October 1964. (SRD)

Volume III, Annotated Compendium of Data on Physical and Chemical Properties of Fallout (U), DASA 1251-3 (AD 381963L), 770 pp., November 1966. (SRD)

Volume IV, Annotated Compendium of Data on Radiochemical and Radiation Characteristics of Fallout (U):

Part 1 - Specific Activity, Activity-Size Distribution, Decay (U), DASA 1251-4-1 (AD 500919L), 643 pp., September 1968. (SRD)

Part 2 - Radiochemical Composition, Induced Activity, Gamma Spectra (U), DASA 1251-4-2 (AD 523385), 570 pp., 31 May 1972. (SRD)

Volume V, Transport and Distribution of Local (Early) Fallout from Nuclear Weapon Tests (U), DASA 1251-5 (AD 362012), 580 pp., May 1965. (SRD)

Environmental Radiation Protection Factors
Provided by Civilian Vehicles

Vehicle	Position	Protection Factor Range
Commercial bus (common type)	Throughout bus	1.5-2.0
Commercial bus (scenic cruiser type)	Throughout bus	1.5-2.0
School bus	Throughout bus	1.5-1.8
Passenger car	Passenger side (chest)	1.5-1.7
	Driver side	1.5-1.7
Pickup	Driver side	1.9-2.1
Crew cab	Driver side	1.8-2.0
	Back seat	1.8-2.0
Carryall	Driver side	1.7-1.9
	Rear side	1.7-1.9
2-1/2-ton truck	Driver side	1.8-2.0
	Center of bed	1.4-1.6
5-ton truck	Driver side	2.0-2.2
	Sleeper	1.9-2.1
Heavy Truck	Driver side	1.4-1.6
	Center of trailer	2.7-3.1
Fire truck	Driver side	2.7-3.1
	Standing area in back	1.6-1.8
Switch engine	Engineer's seat	3.0-3.5
Railway guard car	Sleeping quarters	2.2-2.6
	Kitchen area	2.4-2.8
	Center area	2.0-2.4
Heavy locomotive	Engineer's seat	3.0-3.5

SOURCE: Z. G. Burson, "Environmental and Fallout Gamma Radiation Protection Factors Provided by Civilian Vehicles," Health Physics, 26, 41-44, 1974.

HOME OFFICE
SCOTTISH HOME DEPARTMENT

MANUAL OF CIVIL DEFENCE

Volume I

PAMPHLET No. 1

NUCLEAR WEAPONS

LONDON
HER MAJESTY'S STATIONERY OFFICE
1956

88 Large buildings with a number of storeys, especially if they are of heavy construction, provide much better protection than small single-storey structures (see Figure 4). Houses in terraces likewise provide much better protection than isolated houses because of the shielding effect of neighbouring houses.

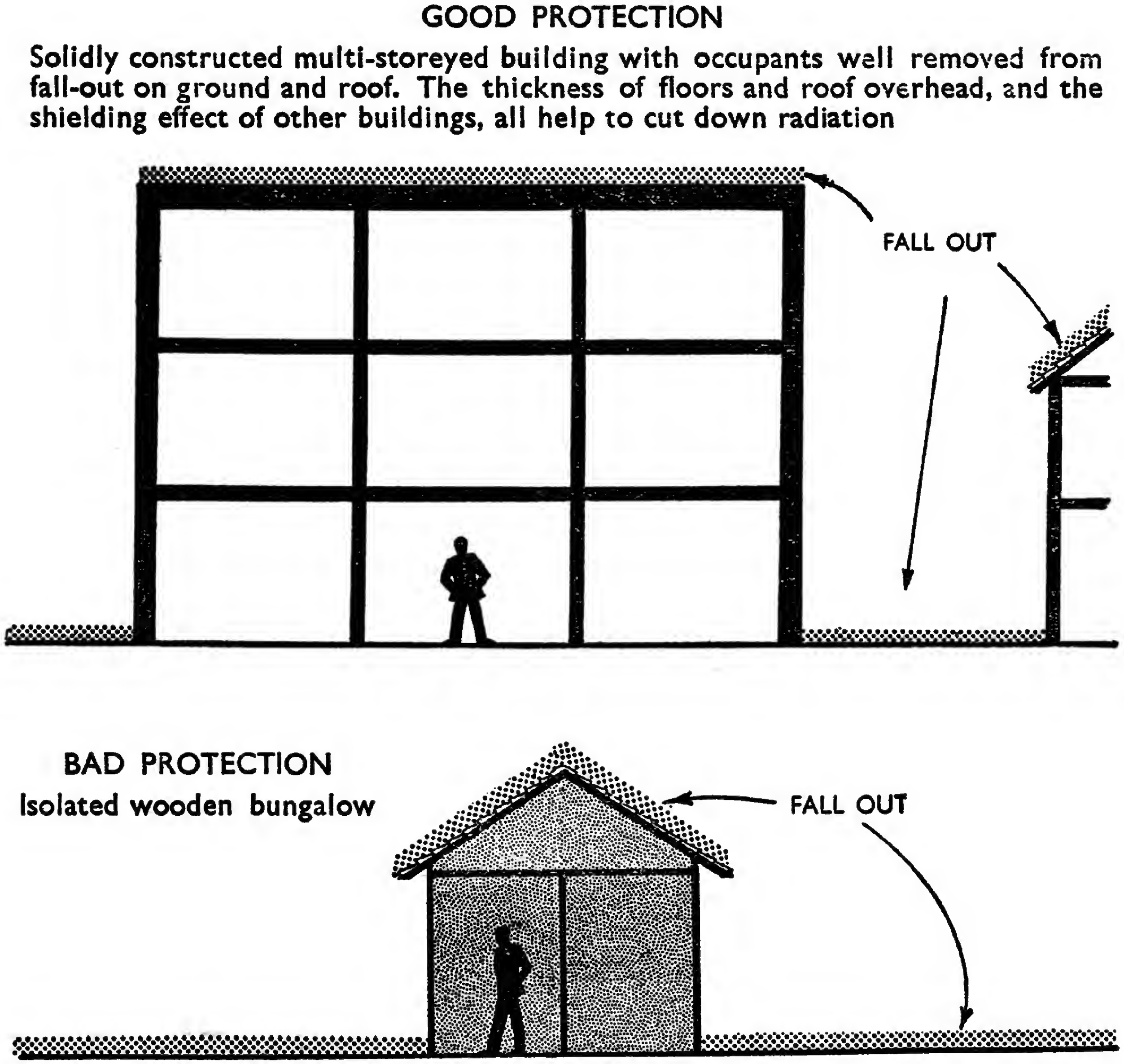


FIGURE 4
Examples of good and bad protection afforded by buildings against fall-out.

89 It is estimated that the protection factor (the factor by which the outside dose has to be divided to get the inside dose) of a ground floor room in a two-storey house ranges from 10 to about 50, depending on wall thickness and the shielding afforded by neighbouring buildings. The corresponding figures for bungalows are about 10–20, and for three-storey houses about 15–100. An average two-storey brick house in a built-up area gives a factor of 40, but basements, where the radiation from outside the house is attenuated by a very great thickness of earth, have protection factors ranging up to 200–300. A slit trench with even a light cover of boards or corrugated iron without earth overhead gives a factor of 7, and if 1 ft. of earth cover is added the

factor rises to 100. If the trench can be covered with 2 or 3 feet of earth then a factor of more than 200–300 can be obtained (see Figure 5).

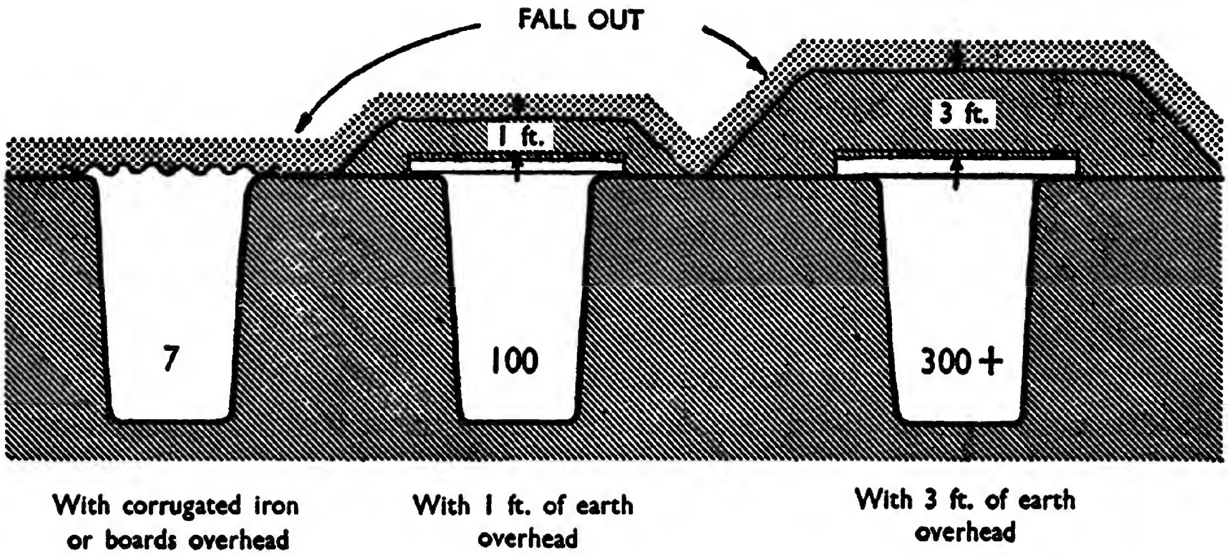


FIGURE 5
Protection factors in slit trenches (the factor by which the outside dose is divided to get the inside dose).

Choosing a refuge room

90 In choosing a refuge room in a house one would select a room with a minimum of outside walls and make every effort to improve the protection of such outside walls as there were. In particular the windows would have to be blocked up, e.g. with sandbags. Where possible, boxes of earth could be placed round an outside wall to provide additional protection, and heavy furniture (pianos, bookcases etc.) along the inside of the wall would also help. A cellar would be ideal. Where the ground floor of the house consists of boards and timber joists carried on sleeper walls it may be possible to combine the high protection of the slit trench with some of the comforts of the refuge room by constructing a trench under the floor.
Once a trap door had been cut in the floor boards and joists and the trench had been dug, there would be no further interference with the peace-time use of the room.

Estimated under-cover doses in the fall-out area

91 Taking an average protective factor of 40 for a two-storey house in a built-up area, the doses accumulated in 36 hours for the ranges referred to in the U.S. Atomic Energy Commission Report (paragraph 84) would have been:—

190 miles downwind	$7\frac{1}{2}$r	15 Megatons
160 ,, ,,	$12\frac{1}{2}$r	Bravo 1954
140 ,, ,,	20r	

which are all well below the lowest figure of 25r referred to in Table 1. At closer ranges along the axis of the fall-out, the doses accumulated in 36 hours would have been much higher, but over most of the contaminated area—with this standard of protection—the majority of those affected would have been saved from death, and even from sickness, by taking cover continuously for the first 36 hours.

5. **Radiation sickness**

Assume dose incurred in a single shift (3–4 hours) by the "average" man, over the whole body:—

25 roentgens		—No obvious harm.
100 ,,		—Some nausea and vomiting.
500 ,,		—Lethal to about 50 per cent. people (death up to 6 weeks later).
800 ,,	or more	—Lethal to all (death up to 6 weeks later).

Note: If dose spread uniformly over 2–3 days, then 60 roentgens could be incurred with no more effect than 25 roentgens in a single exposure of 3–4 hours.

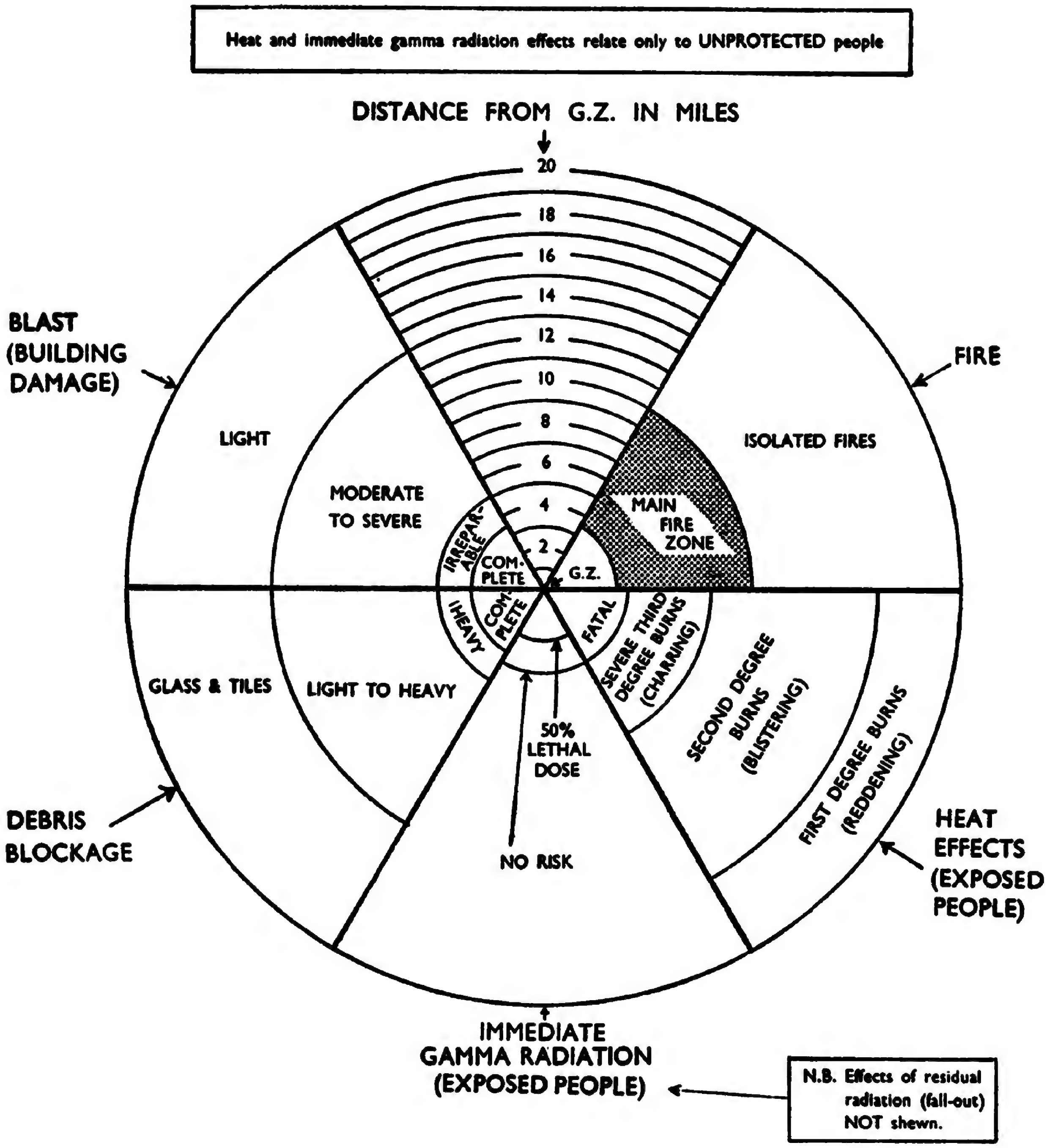


FIGURE 11

Combined effects (excluding residual radioactivity) from a 10 megaton ground burst bomb. Heat and immediate gamma radiation effects relate only to UNPROTECTED people.

HOME OFFICE
SCOTTISH HOME DEPARTMENT

MANUAL OF CIVIL DEFENCE

Volume I

PAMPHLET No. 2

RADIOACTIVE FALL-OUT

PROVISIONAL SCHEME OF PUBLIC CONTROL

LONDON
HER MAJESTY'S STATIONERY OFFICE
1956

Radioactive Fall-out—Summary of Provisional Control Zones

Zone	Definition of Zone Boundaries	Range of Cumulative Doses in open at 48 hours	Summary of permissible and recommended action	Range of Cumulative Doses assuming observance of control rules
W	Outer: Limit of area placed under "Black Warning" (*see* Footnote). Inner: 0·3 r.p.h. at 48 hrs.	Up to 80r	Complete release from refuge as soon as dose-rate fell to 0·3 r.p.h. or, if the rate had not reached that figure, when fall-out was complete.	At 48 hrs. Below 2r
X	Outer: 0·3 r.p.h. at 48 hrs. Inner: 3 r.p.h. at 48 hrs.	80–800r	Qualified release from refuge after 48 hrs.—indoor workers to follow normal occupations, but not to exceed 4 hrs. per day in the open. Outdoor workers to work half shifts for next five days. At the end of this period the zone would be normal, except that all would be advised to be out of doors as little as possible and not in any case to exceed 8 hrs. per day in the open for the next three months.	At 48 hrs. 2-20r At 7 days 6-60r At 5 wks. 12-120r At 3 mths. 14-145r
Y	Outer: 3 r.p.h. at 48 hrs. Inner: 10 r.p.h. at 48 hrs.	800-2,800r	Release from refuge under stringent control after 48 hrs. For the next 12 days people should not leave their refuge for longer than necessary. Time in the open should not exceed 2 hrs. per day and time under cover, but not in refuge, a further 8 hrs. On this basis essential indoor workers should be able to get to their places of work, but outdoor work would remain suspended; a relaxation would be possible after the first fortnight and further easement in another three weeks. For the rest of the first year, however, people in this zone should not exceed 8 hrs. a day in the open.	At 48 hrs. 20-70r At 14 days 50-170r At 5 wks. 70-240r At 3 mths. 95-330r
Z	10 r.p.h. at 48 hrs.	Above 2,800r	All movement outside refuge accommodation in this zone would be dangerous. People should remain in refuge until instructions for clearance were given—they should then leave the zone by the quickest available route if they had means of transport or wait in their refuge to be collected if they had not. The clearance operation might start after 48 hrs. and removal from the zone would be for at least 3 months.	At 48 hrs.—Above 70r

The initial Zone W boundary would be defined by the boundaries of a series of warning districts on the flanks of the fall-out. After 48 hrs. Zone W would for public control purposes have disappeared: its outer boundary would have moved during the period to coincide with the outer boundary of Zone X.

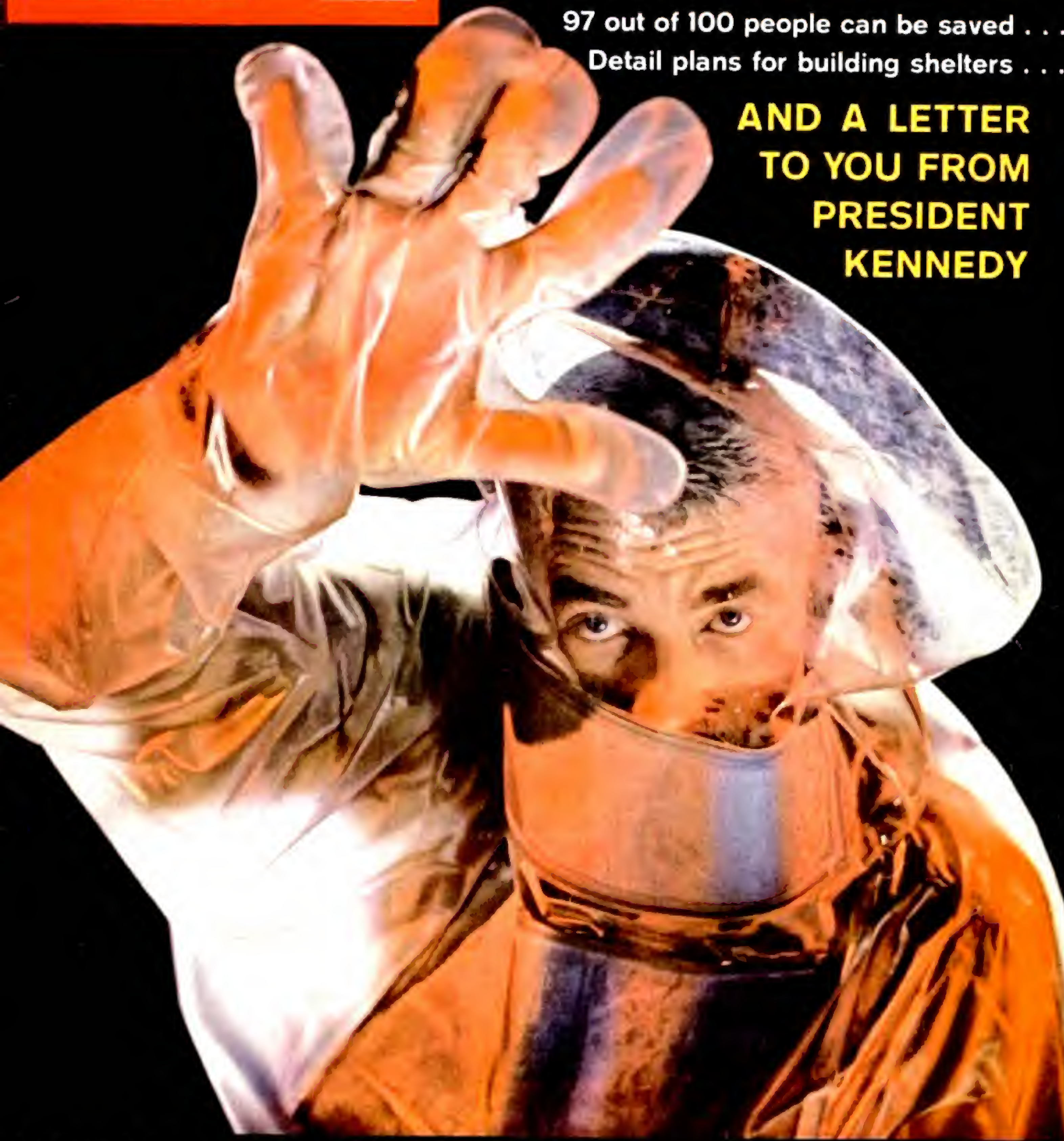
The question of defining an area extending in some places beyond Zone W in which there might be an agricultural hazard is being studied.

LIFE

HOW YOU CAN
SURVIVE FALLOUT

97 out of 100 people can be saved . . .
Detail plans for building shelters . . .

AND A LETTER
TO YOU FROM
PRESIDENT
KENNEDY



CIVILIAN FALLOUT SUIT

SEPTEMBER 15 · 1961 · 20¢

A MESSAGE TO YOU FROM THE PRESIDENT

The White House
September 7, 1961

My Fellow Americans:

Nuclear weapons and the possibility of nuclear war are facts of life we cannot ignore today. I do not believe that war can solve any of the problems facing the world today. But the decision is not ours alone.

The government is moving to improve the protection afforded you in your communities through civil defense. We have begun, and will be continuing throughout the next year and a half, a survey of all public buildings with fallout shelter potential, and the marking of those with adequate shelter for 50 persons or more. We are providing fallout shelter in new and in some existing federal buildings. We are stocking these shelters with one week's food and medical supplies and two weeks' water supply for the shelter occupants. In addition, I have recommended to the Congress the establishment of food reserves in centers around the country where they might be needed following an attack. Finally, we are developing improved warning systems which will make it possible to sound attack warning on buzzers right in your homes and places of business.

More comprehensive measures than these lie ahead, but they cannot be brought to completion in the immediate future. In the meantime there is much that you can do to protect yourself—and in doing so strengthen your nation.

I urge you to read and consider seriously the contents of this issue of LIFE. The security of our country and the peace of the world are the objectives of our policy. But in these dangerous days when both these objectives are threatened we must prepare for all eventualities. The ability to survive coupled with the will to do so therefore are essential to our country.

John F. Kennedy

Fallout Shelters

YOU COULD BE AMONG THE 97% TO SURVIVE IF YOU FOLLOW ADVICE ON THESE PAGES . . . HOW TO BUILD SHELTERS . . . WHERE TO HIDE IN CITIES . . . WHAT TO DO DURING AN ATTACK

PERSONAL AND FAMILY SURVIVAL

SM-3-11

"...the history of this planet and particularly the history of the 20th Century is sufficient to remind us of the possibilities of an irrational attack, a miscalculation, and accidental war, or a war of escalation in which the stakes by each side gradually increase to the point of maximum danger which cannot be either foreseen or deterred. It is on this basis that civil defense can be readily justified—as insurance for the civilian population in case of enemy miscalculation. It is insurance we trust will never be needed—but insurance which we would never forgive ourselves for foregoing in the event of catastrophe."

— President Kennedy, in May 1961

Remove doors from their hinges and place them over supports

Drinking-water is required for survival. It is also useful as a shielding material. A collapsible children's swimming pool filled with water and located over the best corner of your basement will help improve the fallout protection. A bathtub, if suitably located, can also be used for this purpose.

DEPARTMENT OF DEFENSE
OFFICE OF CIVIL DEFENSE

Printed for the Cabinet. December 1954

The circulation of this paper has been strictly limited. It is issued for the personal use of ....Minister of Education..........

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C. (54) 389 UK NATIONAL ARCHIVES: CAB 129/72

9th December, 1954

CABINET

FALL-OUT

MEMORANDUM BY THE MINISTER OF DEFENCE

H. M.

Ministry of Defence, S.W. 1,
7th December, 1954.

EFFECTS OF THE EXPLOSION OF A THERMO-NUCLEAR BOMB

	Air Burst 10 M.T. at 20,000 feet (Radius in miles)	Ground Burst 10 M.T. (Radius in miles)
(*a*) Surface devastation to ordinary brick houses	7½	5½
(*b*) Devastation to facilities and tunnels below ground	Nil	¼ mile in radius and depth
(*c*) Major structural damage to brick houses	9	6¾
(*d*) Surface damage by fire on ordinary day	8–12	5–9

There will be an inner zone of approximately 270 square miles in area (larger than Middlesex), in which radiation will be so powerful that all life will be extinguished, whether in the open or in houses.

Outside this central zone, the density cf radiation will diminish progressively with distance from the point of burst, but the rate of diminution in any particular direction depends on the prevailing wind. Within an area of about 3,000 miles, which with a steady 20-knot wind would be 170 miles long in the direction of the wind and over 20 miles wide in places, exposure in the open on the first day might easily be fatal. Rescue operations could commence on the outer fringes on the second day and thereafter proceed with gathering momentum but the greater part of the area would be immobilised for several days. Survival in this area depends on cover. The efficiency of the cover depends on the weight of the screening material. A thickness of 12 inches of earth would reduce the radiation dosage rate by a factor of about 15. Suitably screened shelter in an ordinary well-bricked house can reduce the dosage rate by a factor as high as 20.

There will be an outer area of 2,000–3,000 square miles in which there is a danger of radiation sickness if no precautions are taken. In general, it would be sufficient for people to stay indoors for about 12 hours after the onset of contamination.

Planning for survival

Stay at Home

Your own local authority will best be able to help you in war.
If you move away – unless you have a place of your own to go to or intend to live with relatives – the authority in your new area will not help you with accommodation or food or other essentials.
If you leave, your local authority may need to take your empty house for others to use.
So stay at home.

Plan a Fall-out Room and Inner Refuge

The first priority is to provide shelter within your home against radioactive fall-out. Your best protection is to make a fall-out room and build an inner refuge within it.

First, the Fall-out room

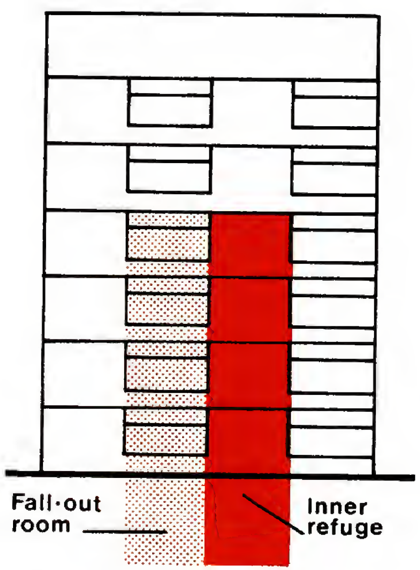
Because of the threat of radiation you and your family may need to live in this room for fourteen days after an attack, almost without leaving it at all. So you must make it as safe as you can, and equip it for your survival. Choose the place furthest from the outside walls and from the roof, or which has the smallest amount of outside wall. The further you can get, within your home, from the radioactive dust that is on or around it, the safer you will be. Use the cellar or basement if there is one. Otherwise use a room, hall or passage on the ground floor.

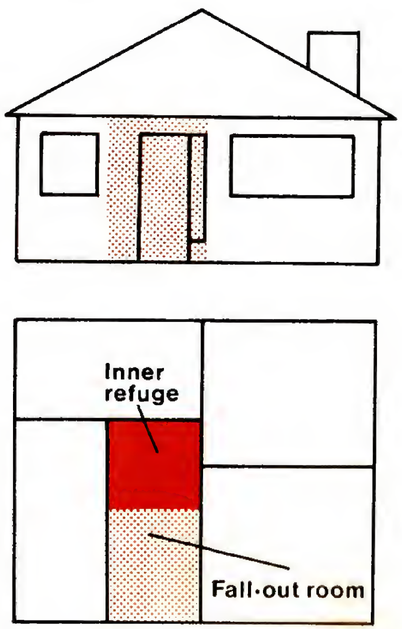
Now the Inner Refuge

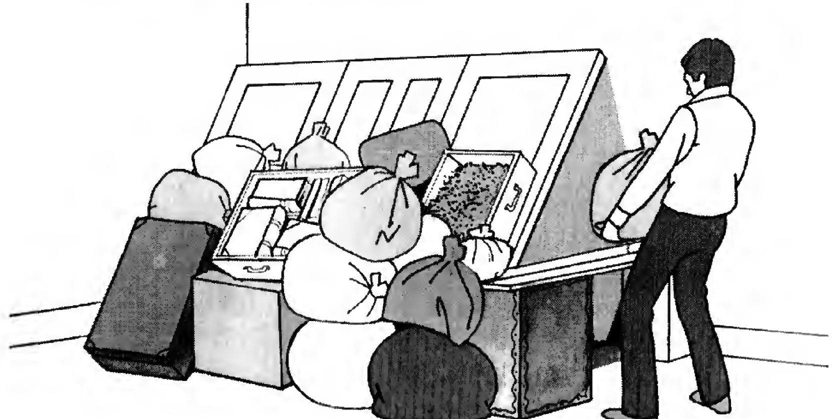
Still greater protection is necessary in the fall-out room, particularly for the first two days and nights after an attack, when the radiation dangers could be critical. To provide this you should build an inner refuge. This too should be thick-lined with dense materials to resist the radiation, and should be built away from the outside walls.

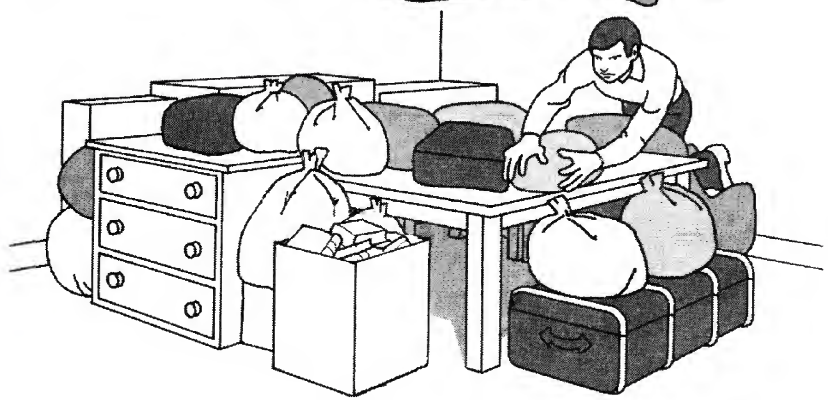
Here are some ideas:

Make a 'lean-to' with sloping doors taken from rooms above or strong boards rested against an inner wall. Prevent them from slipping by fixing a length of wood along the floor. Build further protection of bags or boxes of earth or sand – or books, or even clothing – on the slope of your refuge, and anchor these also against slipping. Partly close the two open ends with boxes of earth or sand, or heavy furniture.









Protect and Survive
UK Government, May 1980

Proceedings of the Symposium
held at Washington, D. C.
April 19-23, 1965 by the
Subcommittee on Protective Structures,
Advisory Committee on Civil Defense,
National Academy of Sciences—
National Research Council

Protective Structures

for

CIVILIAN POPULATIONS

1966

THE PROTECTION AGAINST FALLOUT RADIATION AFFORDED BY CORE SHELTERS IN A TYPICAL BRITISH HOUSE

Daniel T. Jones
Scientific Adviser, Home Office, London

Protective Factors in a Sample of British Houses (Windows Blocked)

Protective Factor	Percentage of Houses
< 25	36%
25-39	28%
40-100	29%
> 100	7%

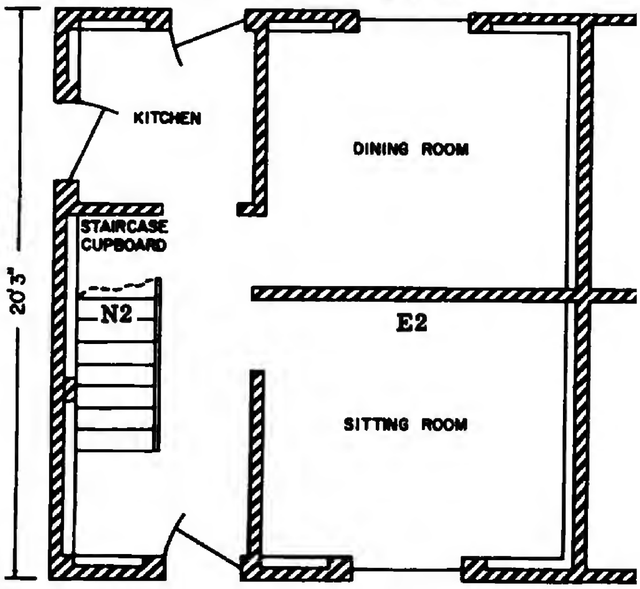
"A very much improved protection could be obtained by constructing a shelter core. This means a small, thick-walled shelter built preferably inside the fallout room itself, in which to spend the first critical hours when the radiation from fallout would be most dangerous."(1)

The full-scale experiments were carried out at the Civil Defense School at Falfield Park.(2)

In the staircase construction, the shelter consisted of the cupboard under the stairs, sandbags being placed on treads above and at the sides.

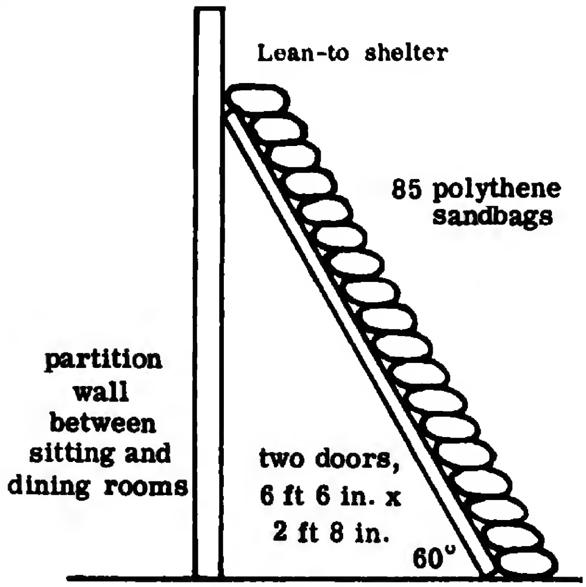
A 93 curies cobalt-60 source was used.

1. Six sandbags per tread, and a double layer on the small top landing. 96 sandbags were used.
2. As (1), together with a 4-ft-high wall of sandbags along the external north wall. 160 sandbags were used.
3. As (2), together with 4-ft-high walls of sandbags along the kitchen/cupboard partition wall and along the passage partition. 220 sandbags were used.



9 in. brick walls The windows and doors were not blocked	Position	contribution r/hr/c/ft² Ground	Roof	Protective Factor
House only	E2	15.0	8.4	21
Lean-to	E2	10.4	2.4	39
Staircase cupboard:				
Stairs only sandbagged	N2	29.2	5.3	14
Stairs and outer wall sandbagged	N2	16.4	4.6	24
Stairs, outer wall, kitchen wall and corridor partition sandbagged	N2	8.8	1.8	47

sandbags 24 in. x 12 in. when empty; 16 in. x 9 in. x 4 in. when filled with 25 lb of sand.



floor area 21 sq ft.

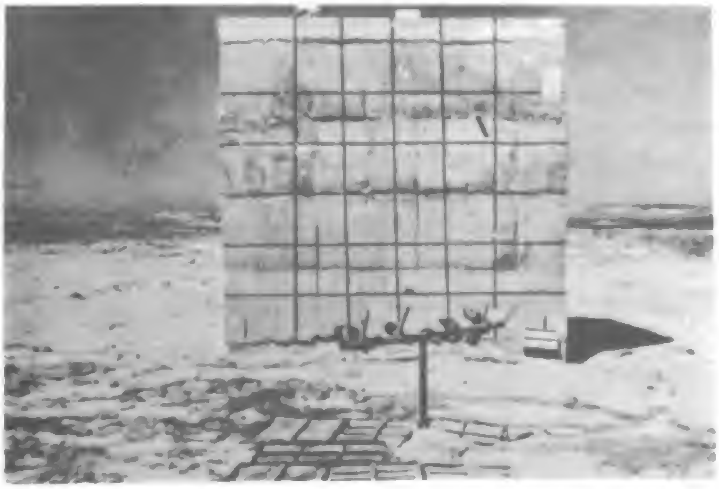
1. Civil Defence Handbook No. 10, HMSO, 1963.
2. Perryman, A. D., Home Office Report CD/SA 117.

MODEL ANALYSIS

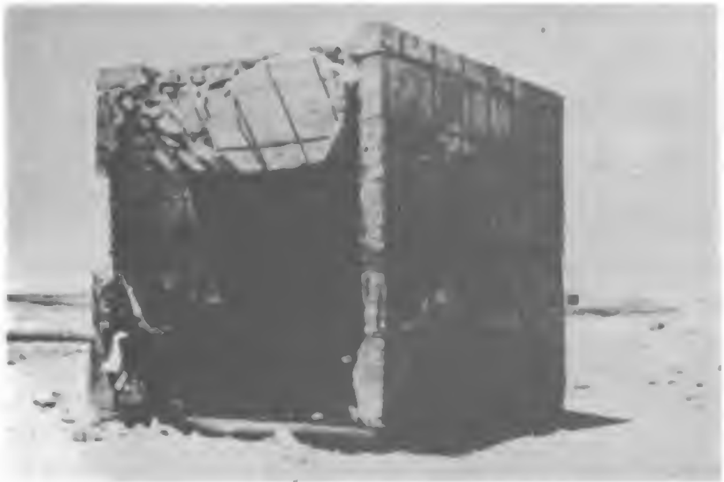
Mr. Ivor Ll. DAVIES
Suffield Experimental Station
Canadian Defense Research Board
Ralston, Alberta, Canada

Nuclear-Weapon Tests

In 1952 we fired our first nuclear device, effectively a "nominal" weapon, at Monte Bello, off northwest Australia. To the blast loading from this weapon we exposed a number of reinforced-concrete cubicle structures that had been designed for the dynamic loading conditions, and for which we made the best analysis of response we were competent to make at that time. Our estimates of effects were really a dismal failure. The structures were placed at pressure levels of 30, 10, and 6 psi, where we expected them to be destroyed, heavily damaged with some petaling of the front face, and extensively cracked, respectively. In fact, the front face of the cubicle at 30 psi was broken inwards; failure had occurred along both diagonals, and the four triangular petals had been pushed in. At the 10-psi level, where we had three cubicles, each with a different wall thickness (6, 9, and 12 in.), we observed only light cracking in the front face of that cubicle with the least thick wall (6 in.). The other two structures were apparently undamaged, as was the single structure at the 6-psi level.



10 p.s.i.



34 p.s.i.

Dynamic tests, Monte Bello cubicles.

In 1957, the first proposals were made for the construction of the underground car park in Hyde Park in London. The Home Office was interested in this project since, in an emergency, the structure could be used as a shelter. Consequently a request was made to us at Atomic Weapons Research Establishment (A.W.R.E.) to design a structure that would be resistant to a blast loading of about 50 psi, and to test our design on the model scale.

Using the various load-deformation curves obtained in this test, an estimate was made of the response of the structure to blast loading. Of particular interest was the possible effect of 100 tons of TNT, the first 100-ton trial at Suffield in Alberta.

A total of seven more models was made; six were shipped to Canada and placed with the top surface of the roof flush with the ground and at positions where peak pressures of 100, 80, 70, 60, 50, and 40 psi were expected. The seventh model was kept in England for static testing at about the time of firing. The results were not as expected. In the field, the four models farthest from the charge were apparently undamaged; we could see no cracking with the eye, nor did soaking the models with water reveal more than a few hair cracks. The model nearest the charge was lightly cracked in the roof panels and beams, and one of the columns showed slight spalling at the head. This model had been exposed to a peak pressure of 110 psi.

Davies, I. Ll., Effects of Blast on Reinforced Concrete Slabs, and the Relationship with Static Loading Characteristics (U). United Kingdom, Operation BUFFALO - Target Response Tests, AWRE Report T 46/57 (CONFIDENTIAL report), August 1957.

Wood, A. J., The Effect of Earth Covers on the Resistance of Trench Shelter Roofs (U). United Kingdom, Operation BUFFALO-Target Response Target Response Tests, AWRE Report T 47/57 (CONFIDENTIAL report), August 1957.

O'Brien, T. P., Rowe, R. D., and Hance, R. J., The Effect of Atomic Blast on Wall Panels (U). United Kingdom, FWE-36 (CONFIDENTIAL report), April 1955.

Walley, F., Operation TOTEM Group 13 Report: Civil Defense Structures (U). United Kingdom, FWE-111 (CONFIDENTIAL report), May 1957.

Davies, I. Ll., and Thumpston, N. S., The Resistance of Civil Defense Shelters to Atomic Blast (U). United Kingdom, FWE 35 (UNCLASSIFIED report), March 1955.

Davies, I. Ll., The Resistance of Civil Defense Shelters to Atomic Blast: IV Final Report on Experiments with Reinforced Models of Heavily Protective Citadel Shelter Type CD12 (U). United Kingdom, FWE-101 (CONFIDENTIAL report), May 1958.

Davies, I. Ll., Performance Test on Model Garage - Shelter Roof System. SES 100 Ton TNT Trial-Suffield, Alberta, August 1961 (U). United Kingdom, AWRE Report No. E 2/63 (FOR OFFICIAL USE ONLY), March 1963.

Worsfold, W. E., Effects of Shielding a Building from Atomic Blast (U). United Kingdom, FWE-164 (CONFIDENTIAL report), August 1958.

Trimer, A., and Maskell, E. G. B., Operation BUFFALO Target Response Tests - Structures Group Report: The Effect on Field Defenses (U). United Kingdom, FWE-241 (CONFIDENTIAL report), December 1959.

United Kingdom, The Effects of Atomic Weapons on Structures and Military Equipment (U). FWE-8 (SECRET report), July 1954.

BLAST AND OTHER THREATS

Harold Brode
The RAND Corporation, Santa Monica, California

Chemical High-Explosive Weapons

As in past aerial warfare, bombs and missiles carrying chemical explosives to targets are capable of extensive damage only when delivered in large numbers and with high accuracy.

Biological Warfare

Most biological agents are inexpensive to produce; their effective dissemination over hostile territories remains the chief deterrent to their effective employment. Twenty square miles is about the area that can be effectively covered by a single aircraft; large area coverage presents a task for vast fleets of fairly vulnerable planes flying tight patterns at modest or low altitudes. While agents vary in virulence and in their biologic decay rate, most are quite perishable in normal open-air environments. Since shelter and simple prophylactic measures can be quite effective against biological agents, there is less likelihood of the use of biological warfare on a wholesale basis against a nation, and more chance of limited employment on population concentrations —perhaps by covert delivery, since shelters with adequate filtering could insure rather complete protection to those inside.

Chemical Weapons

Chemical weapons, like biological weapons, are relatively inexpensive to create, but face nearly insurmountable logistics problems on delivery. Although chemical agents produce casualties more rapidly, the greater amounts of material to deliver seriously limit the likelihood of their large-scale deployment. Furthermore, chemical research does not hold promise of the development of significantly more toxic chemicals for future use.

Radiological Weapons

The advantages of such modifications are much less real than apparent. In all weapons delivered by missiles, minimizing the payload and total weight is very important. If the total payload is not to be increased, then the inclusion of inert material to be activated by neutrons must lead to reductions in the explosive yield. If all the weight is devoted to nuclear explosives, then more fission-fragment activity can be created, and it is the net difference in activity that must be balanced against the loss of explosive yield. As it turns out, a fission explosion is a most efficient generator of activity, and greater total doses are not achieved by injecting special inert materials to be activated.

Perret, W.R., Ground Motion Studies at High Incident Overpressure, The Sandia Corporation, Operation PLUMBBOB, WT-1405, for Defense Atomic Support Agency Field Command, June 1960.

The Neutron Bomb

The neutron bomb, so called because of the deliberate effort to maximize the effectiveness of the neutrons, would necessarily be limited to rather small yields—yields at which the neutron absorption in air does not reduce the doses to a point at which blast and thermal effects are dominant. The use of small yields against large-area targets again runs into the delivery problems faced by chemical agents and explosives, and larger yields in fewer packages pose a less stringent problem for delivery systems in most applications. In the unlikely event that an enemy desired to minimize blast and thermal damage and to create little local fallout but still kill the populace, it would be necessary to use large numbers of carefully placed neutron-producing weapons burst high enough to avoid blast damage on the ground, but low enough to get the neutrons down. In this case, however, adequate radiation shielding for the people would leave the city unscathed and demonstrate the attack to be futile.

The thermal radiation from a surface burst is expected to be less than half of that from an air burst, both because the radiating fireball surface is truncated and because the hot interior is partially quenched by the megatons of injected crater material.

SUPERSEISMIC GROUND-SHOCK MAXIMA (AT 5-FT DEPTH)

Vertical acceleration: $\alpha_{vm} \simeq 340\,\Delta P_s/C_L$ ± 30 per cent. Here acceleration is measured in g's and overpressure (ΔP_s) in pounds per square inch. An empirical refinement requires C_L to be defined as the seismic velocity (in feet per second) for rock, but as three fourths of the seismic velocity for soil.

OUTRUNNING GROUND-SHOCK MAXIMA (AT ~10-FT DEPTH)

Vertical acceleration: $\alpha_{vm} \simeq 2 \times 10^5/C_L r^2$ + factor 4 or -factor 2. Acceleration is measured in g's, and r is the scaled radial distance—i.e., $r = R/W^{1/3}$ kft/(mt)$^{1/3}$.

Data taken on a low air-burst shot in Nevada indicate an exponential decay of maximum displacement with depth. For the particular case of a burst of ~ 40 kt at 700 ft, some measurements were made as deep as 200 ft below the surface of Frenchman Flat, a dry lake bed, which led to the following approximate decay law, according to Perret.

$\delta = \delta_0 \exp(-0.017D)$,

where δ represents the maximum vertical displacement induced at depth D, δ_0 is the maximum displacement at the surface, and D is the depth in feet.

NUMBER AND CLASSIFICATION OF OFFICIAL EVACUEES IN GREAT BRITAIN IN 1939 AND 1940

900,000 of the 1.5 million returned to the target areas after four months of war.	September, 1939		January, 1940	
	Number	Percentage Distribution	Number	Per cent of Those in September, 1939
1. Unaccompanied school children	826,959	56.1	457,600	55
2. Mothers and accompanied children	523,670	35.5	64,900	12
3. Expectant mothers	12,705	0.9	1,140	9
4. Blind persons, cripples, and other special classes	7,057	0.5	2,440	35
5. Teachers and helpers	103,000	7.0	46,500	45
Total	1,473,391	100.0	572,580	39

Source: R. M. Titmuss, *Problems of Social Policy* (London: H.M. Stationery Office, 1950), pp. 103 and 172.

Effectiveness of Some Civil Defense Actions in Protecting Urban Populations (u)

Appendix B of Defense of the US against Attack by Aircraft and Missiles (u)

ORO-R-17, Appendix B

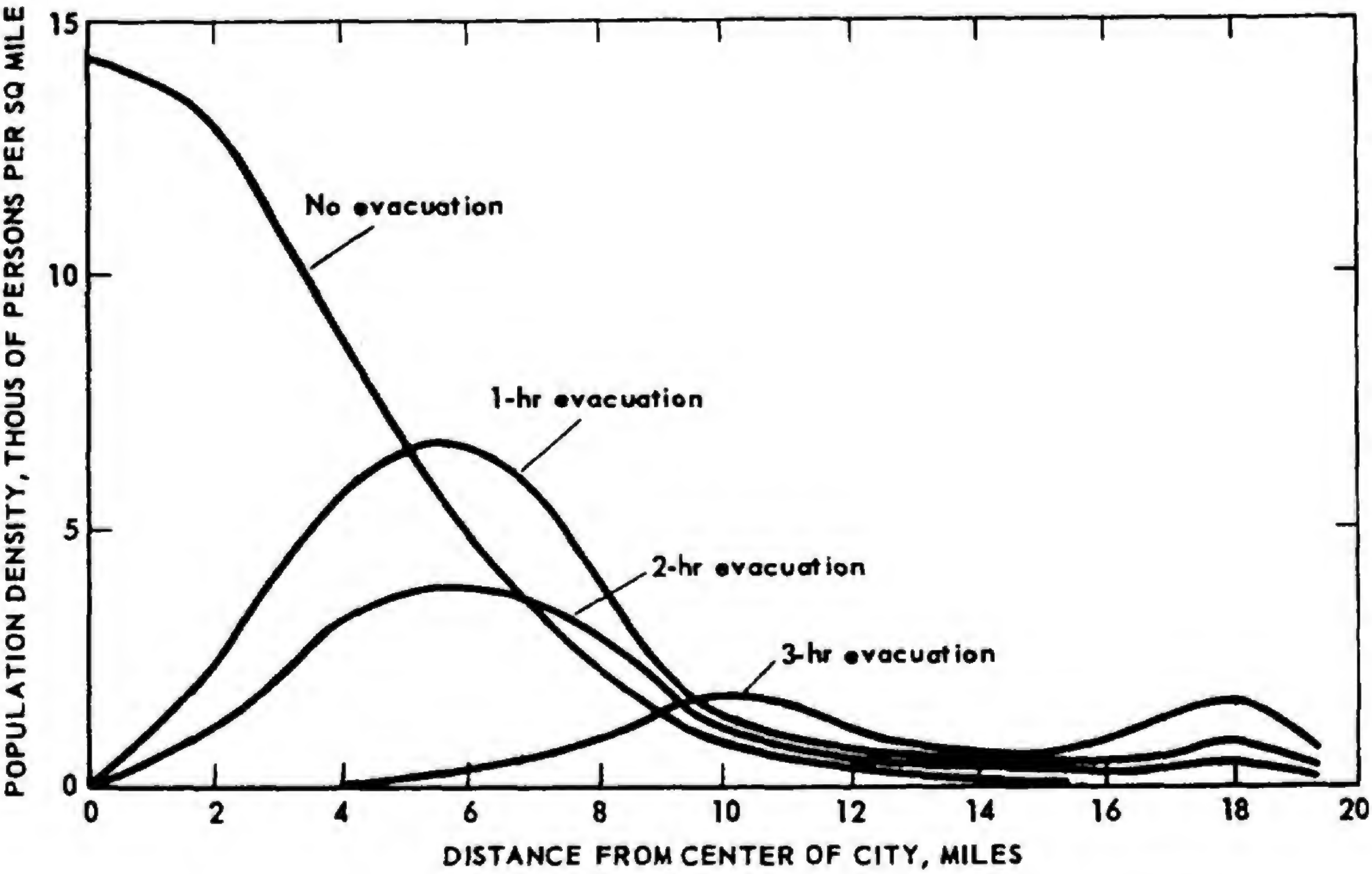


Fig. 10 — Population Density of Washington Target as Function of Distance from Center of City for Three Evacuation Times

In Britain, by early 1940, the government had issued free, to families of low income, some 2.3 million bomb shelters, enough to shelter over one-fourth of the population. But by the same time -- after Munich had brought home to the British people the peril in which they stood, even after the war had begun -- less than 1000 shelters had been *purchased*. This was under 0.04 per cent of the total number in place, despite the fact that the shelters were sold at cost.[7]

For protection against chemical and biological attack, our National Plan proposes that protective (gas) masks be made "...available to the people through regulated commercial distribution...."[8] or in a word, sold. That too is nonsense. In Britain, in contrast, the government had decided by 1935 that it would be futile to expect the population to buy their own masks. During the Munich crisis, 38 million gas masks were issued free to the people of Great Britain.[9] The British government of that time could scarcely be called war-minded or over-prepared for war. Still less, it appears, are we prepared in 1961.

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7. O'Brien, Terence H., *Civil Defence,* London, HMSO, 1955 at 335. In 1939 the government had decided to issue Anderson (corrugated steel) shelters free to householders with incomes of not over £ 250 a year. *Id.*, 188.

8. OCDM National Plan, Annex 24, "National Biological and Chemical Warfare Defense Plan," at 6.

9. O'Brien, *op. cit. supra* note 7 at 165.

-- The Argument That Increased Spending for Nonmilitary and Other Defenses May Cause an Economic Decline

A celebrated statesman not many years ago elegantly put (or rather, asserted) the argument for "national bankruptcy":

CHAMBERLAIN IN LATE 1936 WHEN CHANCELLOR OF THE EXCHEQUER

> If we were now to follow [X's] advice and sacrifice our commerce to the manufacture of arms, we should inflict a certain injury on our trade from which it would take generations to recover, we should destroy the confidence which now happily exists, and we should destroy the revenue.... [33]

And, a comment on that argument,

> It was held very strongly that financial stability was our fourth, and final, military arm, that we must balance [the national budget], and avoid interference... with trade.... [34]

The statement quoted was not made in 1949, when not muscle but fat was being pared from our military budgets. It was not made in 1955 or 1960. It was made, rather, in the 1930's. The statesman who so anxiously viewed the dangers to be apprehended from increased expenditure for arms was Neville Chamberlain. "X" was Winston Churchill. Britain was, if not "generations," at any rate half a generation in paying the bill for Chamberlain's economics. Only recently have her trade, revenue and financial stability recovered from the economies of Stanley Baldwin and Neville Chamberlain.

33. Feiling, Keith, The Life of Neville Chamberlain, London, Macmillan, 1946 at 314. Quotation reproduced by kind permission of the author, MacMillan & Company Ltd. and St. Martin's Press, Inc.

34. Id. at 316.

--The Question of Public Apathy--British Experience Before World War II Compared

The view is often expressed that the population is apathetic, or even hostile, towards nonmilitary defense, and that nothing can be done to develop these defenses until public apathy changes to concern. This view was succinctly put by a member of the House committee which passes on budget requests for OCDM. He said in March, 1959, that, "The Congress is not going to shove something down the throats of the people that they are not interested in. If you did, the Members of Congress would not be here very long."[46]

13

A nation-wide opinion survey by the Institute for Social Research of the University of Michigan, made in 1957, revealed, among other things, that 68 per cent of the population favored planning to evacuate cities, and that 90 per cent favored constructing shelters for people who lived in areas that might be attacked.[47]

Whatever the present reaction of the public might be to a program for nonmilitary defense, it is nearly certain that after a frightening crisis had occurred, the public would not only demand these programs, but would be highly critical of a government which had not taken the necessary action. This, at least, was the experience in Britain.

Munich, however, changed all that. War seemed so imminent that the government ordered day and night digging on trenches in parks and open areas. It issued gas masks to some 38 million citizens.[50] Then, when fitting gas masks and digging trenches had given the citizens personal proof of the threat which hung over them, "Fatalism about providing effective protection against air attack was... replaced by a feeling that this could be done, if the authorities showed enough will and energy."[51]

14

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46. U.S. House, Committee on Appropriations, Hearings, Independent Offices Appropriations, 1960, 86th Cong., 1st Sess. (1959) at 486.

47. Pohlenz, D. Dean, "Problems of Civil Defense Preparedness -- A Policy for Today," Washington, Industrial College of the Armed Forces Student Exercise M57-83 (1957) at 33.

49. O'Brien, Terence H., History of the Second World War: Civil Defence, London, HMSO, 1954 at 93, 99 and 104.

50. Id. at 161 and 165.

51. Id. at 166.

Bertrand Russell, for example, wrote in 1959 that,

> On the most favourable hypothesis, [the postwar world] would consist of destitute populations, maddened by hunger, debilitated by disease... incapable of supporting educational institutions, and rapidly sinking to the level of ignorant savages. This, I repeat, is the most optimistic forecast which is in any degree plausible.[61] [Emphasis added.]

This notion of the extinction of civilization, or even of all life, is a comforting one.[63] Most important, it ensures that a nuclear war will never be fought, since no sane (or perhaps even moderately insane) national leader would consider thermonuclear war as an instrument of policy. Also, if there is really nothing that can be done to mitigate the effects of nuclear war, rational men need not trouble themselves about the problems of preparing nonmilitary defenses -- or of paying for them.

The theory that thermonuclear war automatically results in world annihilation has had, and still has, some highly respectable adherents. In 1955, for example, fifty-two Nobel laureates subscribed to the statement that unless all nations renounced the use of force, they would simply "... cease to exist."[64] Writers on disarmament in 1961 continue to point out that it would be impossible to "... protect [civilians not killed by the initial attack on cities] against fallout and starvation,"[65] and that "Proponents of the arms race are willing to risk the destruction of civilized society...."[66]

--The View That National Security Can Best Be Achieved by Buying Only Offensive and Active Defensive Weapons

61. Russell, Bertrand, Common Sense and Nuclear Warfare, London, copyright (C) 1959 by George Allen and Unwin, Ltd., quotation reproduced by kind permission of Simon and Schuster, Inc. The notion of mutual extermination is also alluded to at 32, and the survivors are characterized as starving and debilitated at 26.
62. On Thermonuclear War, 35.
63. Id. at 11.
64. Id. at 9. Compare Bertrand Russell's views, supra note 61.
65. Sohn, Louis B., "Security Through Disarmament," 192 The Nation 159-163 at 159 (February 25, 1961).
66. Melman, Seymour, "The 'Arms-Control' Doctrine," 192 The Nation 114-116 at 116 (February 11, 1961).

Clark, Grenville and Louis B. Sohn, World Peace Through World Law (2d ed.), Cambridge, Massachusetts, Harvard University Press, 1960.

-- The Argument That Nonmilitary Defense Would Destabilize the Balance of Terror

To take any steps to protect the population would be to do them a disservice, since it might make war "thinkable" again. And whatever steps were taken, millions or tens of millions would be sure to die.

A variant of the hostage theory is that if we were to embark on a serious program for nonmilitary defense, we should inescapably spread war-mindedness among the American people.[71] Once they were awakened to the possibility, or worse the "thinkability," of war, they would inevitably become more hostile towards the source of the danger, namely, the USSR. They might then be expected, with the American penchant for grasping nettles (those, at any rate, recognized as nettles), to press for a first strike against the Soviet Union.

But other countries, not least the Soviet Union, do have nonmilitary defense programs of substantial value.

It is not, in any case, self-evident that a nonmilitary defense program would have a destabilizing (or unbalancing) effect upon American psychology. If anything, a program which included, for example, building fallout shelters or issuing radiation meters, might, by bringing home the threat of war to the American people in a highly personal way, incline them rather to a sober and pacific than to a war-like psychology. City dwellers might reflect upon the fact that their shelters, at least under any program the United States is likely to undertake in the next five years, would give them not a certainty but only a fair to good chance of survival. Rural residents might reflect upon the prospect of an incursion of refugees from the cities.

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71. Letter from Dean David F. Cavers, Harvard Law School, New York Times, March 20, 1960, page 10E, column 6. See too Brown, Harrison and James Real, Community of Fear, Santa Barbara, California, Center for the Study of Democratic Institutions, 1960.

This whole problem of psychological response to nonmilitary defense clearly requires detailed study by experts. British experience in the Munich and post-Munich period may not be without relevance.[73]

--Would A Nonmilitary Defense Program Injure Prospects for Arms Control?

Finally, there is the question whether a program for nonmilitary defense is compatible with plans for arms control or even disarmament.

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the reverse, it should not hazard the success of any arms control or disarmament negotiations in which the Soviets are seriously interested, and it would stabilize any arms control agreement that might be concluded.

73. See, for example, O'Brien, op. cit. supra note 49 at 329 on response to the anti-gas program, and Titmuss, Richard M., Problems of Social Policy, London, HMSO, 1950 at 29-39 on response to evacuation plans and programs.

Strategy for the Thermonuclear Age

Thermonuclear war is a grisly topic. It is, however, one about which we would do well to think. The argument might be made that research on war may make it somewhat more likely to occur. It is more probable, however, that the reverse is true, that not thinking about thermonuclear war may make it easier to blunder into one -- or what might be even worse, to lose one.

It would be well indeed if nuclear war would be unmistakably so annihilating as to be unthinkable, at least for sane men, as Bertrand Russell and others hold. But it would be unfortunate if this view prevailed only in the West and not in Moscow and Peiping. There is good evidence that it does not, especially in the latter. There is in any case something of schizophrenia about spending tens of billions each year on thermonuclear weapons and their delivery vehicles and then refusing to think about the ways and conditions in which they might be used, or (more hopefully) the ways in which we can best assure, short of surrender, that they will not be used.

The best study to date is Herman Kahn's On Thermonuclear War, published late in 1960.[77] Most of what follows in this chapter draws heavily upon Kahn's work, though it is impossible to do it justice in so

small a space. He analyzes, so far as possible in a quantitative way, the probable or possible causes, courses and effects of thermonuclear wars which might occur in the next decade. Kahn's work has been bitterly attacked, although to date in no very temperate or reasoned fashion. It has been called "a moral tract on mass murder," "permeated with a bloodthirsty irrationality," and its quantitative approach a "Higher Incoherence."[78] It has been said to show "narrowness of vision," and to have about it an "air of unreality."[79] But coherent criticism, reasoned rather than stated, marked by broadness of vision or an air of reality, has yet to appear, certainly in more than fragmentary form.[80]

77. Kahn, Herman, On Thermonuclear War, Princeton, N.J., Princeton University Press, 1960. On U.S. national strategy see too Rowen, op. cit. supra note 36, and Washington Center of Foreign Policy Research, Johns Hopkins University, Study for Senate Committee on Foreign Relations, Developments in Military Technology and Their Impact on United States Strategy and Foreign Policy, 85th Cong., 1st Sess. (Comm. Print 1959).

78. Newman, James R., "A Moral Tract on Mass Murder," The Washington Post, February 26, 1961, page E7, columns 5-8. The level of coherence of Mr. Newman's critique is best left unstated.

79. Wolff, Robert Paul, "The Game of War," 144 The New Republic (February 20, 1961) 9-13.

80. The usual criticism of Kahn's work is that it does not sufficiently take into account political problems. Careful, or even casual, reading of On Thermonuclear War, however, shows that Kahn has a better grasp of political problems than most of his political-scientist critics have of strategy.

We may expect Soviet or Chinese support for "progressive, revolutionary national liberation wars"[83] in such areas as Algeria or the Congo. We may see guerilla action in Southeast Asia or other areas on the periphery of the "Socialist camp." We may even see limited wars, fought without or perhaps even with tactical nuclear weapons. Soviet missiles may be rattled again, as they have been rattled on behalf of Nasser and Castro. (American missiles might also be rattled, though this seems unlikely during the next few years, at least.) Finally, even negotiations for arms control or disarmament may be devices of cold war conflict, as they have too largely been to date.

What Are We Trying to Deter?

Kahn points out that it is critically important to distinguish between deterring an attack upon the United States and attacks or major provocations at other points, for example, a "squeeze" or even armed attack on Berlin. The same weapons, dispositions of weapons, and strategies do not suffice for both ends.

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83. **This was promised in the manifesto issued by the leaders of 81 Communist parties after their meeting in Moscow in late 1960. New York Times, December 7, 1960, pages 14 to 17, with the "progressive revolutionary significance" of "national-liberation wars" noted at page 17, column 7. Premier Khrushchev also adverted to the inevitability of "national liberation wars" in a report delivered January 6, 1961. New York Times, January 19, 1961, page 6, column 4.**

84. **Berlin was noted as a "seat of international provocation" in the late-1960 manifesto. New York Times, December 7, 1960, page 15, column 2. (Any Western posture other than abject surrender is doubtless "provocative" in the communist lexicon.)**

As Kahn has put it, history has a disconcerting way of being "...richer and more imaginative than any scholar."[86]

86. **On Thermonuclear War at 557.**

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It is a fearsome thing to contemplate the risk of 10 or 20 or 120 million Americans, or Americans and Britons, being killed in a war, for example, over two and one-half million West Berliners.

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--Devices to Tide Us Over the Earlier 1960's

The Soviets might not, of course, decide to risk everything, or at any rate a great deal of capital and some millions of their citizens, on our succumbing to postattack coercion. If the Marxist-Leninist dialectic condemns spurning the opportunities offered by history, it also condemns taking excessive risks, a sin termed "adventurism."[109] What can we do to increase the risks to be apprehended from an attack on the United States?

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109. See, for example, Garthoff, Raymond, Soviet Strategy in the Nuclear Age, New York, Praeger, 1958 at 5.

--A $100 Billion Program Including Blast Shelters and Extensive Preparation for Economic Recuperation

The "splendid," $100 billion or more, program is the one which might raise some reasonable Soviet apprehension that we might strike first. This program, including blast shelters into which the urban population could "duck" in a matter of twenty or thirty minutes, would in fact be part of a credible strategic posture allowing us to make a first strike.

(Expensive deep shelters create "Maginot Line" delusions: Hitler simply adapted plans to go around obstructions. Similarly, shelters in Hiroshima were unoccupied due to surprise attack! If you have deep shelters, an enemy will plan surprise attack. It takes 20 min to get into shelters, but only 3 minutes for SLBM submarine missile attack from offshore!)

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--History and Arms Control

The lessons of history, for what they may be worth, include those of 1914, when Europe stumbled into a major war which no power wanted, as a result of a minor war about which only Austria or Serbia were really serious. As Herman Kahn has pointed out, there are disturbing analogies between the years before 1914 and those in which we now live.[158]

(Wrong: the German Kaiser did WANT war and had been planning since 1912 to use any excuse for starting war, implementing Schlieffen's plan!)

--Arms Control for the 1960's

At all events, it is clear that the problems of arms control must have more intelligent, more intensive, and more sustained attention than they have yet had, if we are to avoid repeating something like the disasters of either 1914 or 1933-1939. Views on the approaches required, as noted above, vary widely.

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158. Kahn, On Thermonuclear War 368-370.

It would plainly be futile, in view of the vigorous Soviet pacification of Hungary, or of the Chinese liberation of Tibet, to rely upon "world opinion " (whatever that is) to deter violations. . . .

One sanction might be the prospect of a renewed arms race, triggered by the discovery of violations. But this might not deter cheating, particularly if the party bent on violation believed it could secure a commanding position before the injured party could catch up. (Here we might remember the belated but futile efforts of the British to regain air parity, after Hitler's rapid expansion of the Luftwaffe.)[176]

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176. See, for the history of that dismal episode in the history of the West, Sir Winston Churchill's The Gathering Storm, chapter 7. Kahn points out that if one side obtained a significant lead because of evasion or rapid rearmament after the agreement broke down, it might then "...feel compelled to perform a great public service by arranging to stop the arms race before a dangerous balance of terror was restored. It could do this most reliably by stopping the cause of the arms race -- its opponent. Most writers ignore this situation...." On Thermonuclear War at 230.

Is Nonmilitary Defense Possible?

If nonmilitary defense is necessary, is it possible? In the discussion to this point, it has been assumed that it is. But can one say, with any measure of confidence, that nonmilitary defenses could in fact ensure the survival of most or all of the population? Even if a shelter program could preserve the lives of most Americans against fallout or even blast, would they emerge into a world worth living in, or indeed, possible to live in? What of the genetic effects of war? Would all children be born deformed? What of leukemia, of cancer, or of a shortened span of life? What of strontium-90? What of the standard of living? Would the survivors, and their descendants, be reduced to grubbing out a wretched existence, with our economy shattered beyond hope of repair? What of the social impact of attack? Could we expect that the survivors, as Bertrand Russell has predicted, would "rapidly sink to the level of ignorant savages"?

Further, nonmilitary defense must be designed to cope with widely varying conditions. The nature of the postattack environment would depend upon the weight and pattern of the enemy's attack--which might in turn be influenced by the nonmilitary defense measures we had taken. The areas contaminated by fallout would of course be determined by the winds prevailing on the day of attack, as well as by the enemy's attack pattern. Antiaircraft and antimissile defenses would also affect the nature of the postattack environment.

The major systems analyses of nonmilitary defense so far published are the Rand Report and a more detailed work done by Mr. John Devaney's OCDM Operations Research Office, A Preliminary Analysis of Non-Military

Defense.[186] Both of these studies give some ground for sober confidence that the United States could survive thermonuclear wars in the 1960's and even beyond, given appropriate levels of nonmilitary defense preparation. But much more detailed research remains to be done. There are still major areas of uncertainty in the performance of nonmilitary defense systems. The principal policy suggestion of the Rand study was therefore that the United States undertake a broad program of research and development on nonmilitary defense problems, to cost some $200 million over two or three years.[187]

186. OCDM, A Preliminary Analysis of Non-Military Defense, Battle Creek, Michigan, 1959.

187. Kahn, Herman, et al., R-322-RC 184 at 44. (This is about fifty times the present OCDM annual research appropriation.)
R-322-RC Rand Corporation Report on a Study of Non-Military Defense

--Long-Term Effects of Fallout--Genetic Effects and Life-Shortening, and the Strontium-90 Problem

Even if fallout at first decays rapidly, so that fallout shelters could protect most of the population from immediate death or illness due to radiation, would the longer-term effects of radiation make life as we know it either impossible or insupportable for the survivors? Despite the rapid initial decay of fallout, a relatively small amount of contamination would remain in the environment for a long time. This would include strontium-90, a long-lived isotope produced by nuclear fission.

The Rand Report states that about four per cent of babies are at present stillborn or die shortly after birth, two per cent are malformed and two per cent develop later troubles attributable to genetic defects.[200] If as the result of nuclear war, both parents had been exposed to about 250 roentgens, spread over a long period, their chances of producing a seriously defective living child might increase from four per cent to five per cent.[201]

199. Testimony of Dr. James F. Crow, Professor of Genetics, University of Wisconsin, in 1957 fallout hearings, op. cit. supra note 193 at 1013. More recent experiments show that there is a possibility that radiation received over an extended period may not have as much genetic effect as radiation received over a short period. U.S. Congress, Joint Committee on Atomic Energy, Hearings, Fallout from Nuclear Weapons Tests, 86th Cong., 1st Sess. (1959) at 1566.

200. Kahn, et al., op. cit. supra note 184 at 16.

201. Kahn, On Thermonuclear War at 46.

Strontium-90, produced by fission, falls out over crop and pasture lands, is taken up by plants, and can eventually find its way into human bones, where it may cause bone cancer or, in smaller amounts, cause bone lesions and interfere with bone growth, particularly in children.[204]

204. See generally Kahn, On Thermonuclear War at 63-72.

All of these long-term effects of nuclear war are serious, particularly the strontium-90 problem. It appears, however, that with proper preparation, it should be possible to alleviate them. In chapter 2 the subject of decontamination, or removal of radioactive debris, is discussed. In chapter 3 is discussed a scheme suggested by Herman Kahn to ensure that relatively contaminated food be consumed only by older persons, whom it will not much affect, with the least contaminated food reserved for children and pregnant women.

The Rand Report concludes that "...long-term radiation problems are a less critical threat to the survival of a population than the central short-term problem, namely, how to protect a substantial fraction of the population from the immediate disaster of a nuclear war."[205]

205. Kahn, et al.,

R-322-RC Rand Corporation Report on a Study of Non-Military Defense at 21.

Even if the medical effects of nuclear war might not be insoluble, there remains the problem of economic recovery. Would the survivors be condemned to lives without hope, with standards of living, for most, similar to those of the early years of the industrial revolution?

In the absence of reliable predictions of social response to thermonuclear attack, there is a tendency to lurid speculation. One can too easily visualize society collapsing, with the survivors organizing themselves into robber bands and struggling for the few economic resources remaining, or masses of city dwellers suffering crippling mental breakdown, or mankind rejecting science and technology and reverting to a hunting-and-gathering or at best pastoral existence. Others speculate upon the probability of mass panic or of widespread looting and other criminal behavior.

Just such speculations were made in Britain before the war, and made by sober scientists, government officials and soldiers. The Army Council instructed General Officers Commanding that "the initial preoccupation" of the troops would be "to sustain public morale."[214] At the time of Munich, when evacuation was being considered, "...discussions were held on the question of drafting regular troops into London to keep order and prevent panic...."[215] Gloomiest of all were the predictions of the psychiatrists, who thought that mental casualties might outnumber physical casualties by two or three to one:[216]

> ...the experts foretold a mass outbreak of hysterical neurosis among the civilian population. It was expected that the conditions of life brought about by air raids would place an immediate and overwhelming strain upon the individual. Under this strain, many people would regress to an earlier level of needs and desires. They would behave like frightened and unsatisfied children, and they would demand with the all-or-none vehemence of infants the security, food and warmth which the mother had given in the past.

None of this, of course, occurred. Rather than a dramatic increase in neurosis or mental illness, there was in fact a decrease. Statistics for insanity, suicide, drunkenness and disorderly behavior fell by as much as half.[217] Workers absented themselves from their factories after heavy bombing only when their houses had been damaged or destroyed, and then only for an average of six days.[218]

214. Titmuss, op. cit. supra note 73 at 19.

215. Id. at 30.

216. Id. at 338-339.

217. Id. at 340-341.

218. Id. at 341.

Individual and group protection against chemical attack poses great problems. In World War I, gas was considered one of the most effective means for producing casualties,[117] even though the CW agents used then were far less lethal than the nerve gases developed in Germany prior to World War II. A seven-ton load of nerve gas can reportedly cause casualties over an area fifteen miles wide and twenty-five to fifty miles long, and death over an area of 100 square miles,[119] given weather conditions favorable to the spread of gas clouds.[120] New non-lethal gases are under development, including the so-called psychochemicals, related to compounds used to simulate mental disease, and other incapacitating agents. These agents affect victims by upsetting normal behavior patterns or physiological processes,[121] though their short-term effectiveness appears to suit them more to tactical use against troops than to attack of civilian populations.

117. Rothschild, Brig. Gen. J. "Germs and Gas, the Weapons Nobody Dares Talk About" 218 Harper's Magazine 29 at 30 (June 1959). This article also states, ibid, that 26.8 per cent of AEF casualties were caused by gas. FCDA Technical Bulletin 11-25, "Introduction to Chemical Warfare" (1957) states that mustard gas and other blister gases produced more than 400,000 casualties in the last 16 months of World War I, more than were caused by any other weapon then in use. U.S. House, Committee on Science and Astronautics, Research in CBR, House Report No. 815, 86th Cong., 1st Sess. (1959) states at 4 that some 9 million artillery shells filled with mustard gas produced about 400,000 casualties, which effect was about five times that produced by high explosive shell, on a casualty per ton of shell basis. One should also note that CW casualties in World War I included few deaths. About one-third of U.S. casualties were caused by gas, but only 2 per cent of these died, as compared with 25 percent of nongas casualties. Ibid.

119 U.S. Senate, Committee on Armed Services, Hearings, Civil Defense Program, 84th Cong., 1st Sess. (1955) Part 2 at 800. The 100 square mile figure also appears in ACS, id. at 3.

120. "Inversion" conditions, where air temperatures increase with increase in altitude, are most favorable to the spread of gas clouds, and obtain on clear nights and early mornings until about one hour after sunrise. U.S. Department of the Army, Technical Manual 3-240, Field Behavior of Chemical Agents, Washington, 1951, at 16.

121. U.S. House, Committee on Appropriations, Hearings, Department of Defense Appropriations for 1960, 86th Cong., 1st Sess. (1959) Part 6 at 364-365 and 426-436.

In Great Britain, in contrast, some 44 million masks were distributed by the outbreak of World War II, virtually one per inhabitant, and 1.4 million infants' respirators and 2 million children's masks by January, 1940;[137] 55 million masks are now stockpiled in Britain for issue to civilians.[138] **(They are 1950 designed civilian C7 respirators.)**

Procuring 100 million masks for that part of our population concentrated in urban areas might cost $250 million, at $2.50 per mask, and extensive training in defense against BW and CW would also be required.

137. O'Brien, Terence, Civil Defence, London, HMSO, 1955 at 330. Note that as early as 1935 the British government decided that masks would have to be issued free of charge. Id. at 61.

138. Interview Col. Francis B. Stewart, FCDA (now OCDM), Battle Creek, Michigan, January 30, 1958.

3000 roentgens per hour intensity at one hour
12,000 roentgens outdoor dose in the first year

10,000 r in the first two weeks (emergency phase)
2000 r in the remaining fifty weeks (reclamation phase)

EMERGENCY PHASE (10,000 r)		RECLAMATION PHASE (2000 r)	
Shelter attenuation	10,000 r dose reduced to	Decontamination effectiveness (reduction to)	2000 r dose reduced to
1/100	100	90% (1/10)	200
1/1000	10	99% (1/100)	20

Radiological decontamination involves no very mysterious or sophisticated techniques. In general, fallout material can be swept or flushed off

Evacuation

Contrary to popular belief, the effectiveness of tactical evacuation is by no means destroyed by the ICBM. While it is clear that no tactical evacuation could even be started during the 30-minute flight of an ICBM, it is also true, as the Rand Report points out, that cities are not likely to be attacked with the enemy's first ICBM salvo, and it is quite possible that most cities might not be attacked at all.

As Herman Kahn has pointed out, a national evacuation capability could be of the greatest importance in time of international crisis: If the Soviets evacuated their cities, they would have made it highly credible that they were prepared to go to war unless we backed down.[155]

155. **Kahn, Herman, <u>On Thermonuclear War</u>, Princeton, N.J., Princeton University Press, 1960 at 213-214, also 132. Objections to evacuation and other nonmilitary defense measures are dealt with at 641-651, with objections bearing on evacuation in particular at 648-651.**

The Bureau of Roads in 1956 prepared a report[160] on national evacuation capabilities for 161 urban target areas, containing 90.7 million people, about 55 per cent of the population. The report assumed orderly and disciplined movement, making maximum use of escape routes, and the findings included the following:[161]

(1) In 1 1/2 hours, 32 million persons could be evacuated at least 15 miles from the centers of target areas, over existing highways and streets;

(2) In 4 1/2 hours, 72 million persons could be evacuated at least 15 miles from target area centers;

(3) In 2 hours, 22 million persons could be evacuated at least 25 miles;

(4) In 5 hours, 53 million persons could be evacuated at least 25 miles;

(5) Evacuation of the largest cities within reasonable time limits would not be possible.

In sum, four hours' warning would allow substantial clearance of all but the largest cities, and even in these cities, this warning would allow evacuation of some 9 million of their 48 million inhabitants.[162]

160. **Reprinted and discussed in U.S. House, Committee on Government Operations, <u>Hearings, New Civil Defense Legislation</u>, 85th Cong., 1st Sess. (1957) at 111-136.**

161. **Discussed <u>id</u>. at 124-126.**

162. **OCDM Operations Research Office, <u>A Preliminary Analysis of Nonmilitary Defense</u>, Battle Creek, Michigan, 1959 at 169.**

Since 1956 Great Britain has had a simple scheme for classifying radiation zones by intensity and for evacuating the most dangerous zone, of 1000 r/hr and upwards at H ≠ 1.[171] Such a program is dependent on a monitoring system, so that fallout zones may be delineated and appropriate instructions given their inhabitants. It requires sophisticated and technically competent control, related to the area affected by fallout, not to preattack political subdivisions.

Remedial evacuation also requires detailed arrangements for traffic control, if existing transport within the most dangerous area is relied on for evacuation.

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171. Home Office, Radioactive Fall-out, Provisional Scheme of Public Control, London, HMSO, 1956.

The requirement for rescue forces would depend upon the number of survivors trapped or incapacitated in areas which could be approached by rescue teams. OCDM estimated that in the 1446-megaton attack assumed for the 1959 JCAE hearings, 11.5 million people would have been fatally injured by blast and heat effects and 6.3 million nonfatally injured. Fallout would have caused a further 10.7 million fatal and 10.9 million nonfatal injuries.[175] Many of the blast casualties would require to be rescued and, together with fallout casualties, to be transported from the danger area. Other casualty estimates, however, show markedly fewer blast injuries, on the order of one-fourth of those estimated in the JCAE hearings.[176]

(JCAE hearings used gross Hiroshima casualty data, which applies to people watching the B-29 deliver bomb, i.e. no proper "duck and cover" for elayed blast behind windows.)

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175. 1959 JCAE Hearings, Effects of Nuclear War, at 651.

176. SRI calculations show only 1.6 million blast casualties from a 1500-megaton attack

177. Note that casualty effects are extrapolated from experience at Hiroshima and Nagasaki, which were attacks with air-bursted kiloton weapons. U. S. Atomic Energy Commission, Effects of Nuclear Weapons, Washington, 1957, at 456. Factors which may affect casualty numbers include yield, height of burst, strength of buildings (or shelters,) and the weather at the time of attack. Ibid. It is interesting to note that prewar British estimates of casualties from aerial attack, based on limited experience from World War I, turned out in the event to have been too high by 6 times.

Finally, fallout would limit rescue operations. Fallout from surface bursts far upwind might make operations impossible, if radiation levels were so high that rescue crews could not work without accumulating harmful radiation doses. Even if rescue groups could approach damaged areas from upwind, rescue of severe blast and burn casualties from within six or nine miles of ground zero would not be possible to a significant extent, since the level of contamination even upwind of a surface burst would be so high as to prevent rescue parties from working in these areas for several days at least, by which time most of the seriously injured would have died.[178] It might be possible, however, to organize rescue operations on the first day from upwind into the areas of lighter damage, perhaps fifteen miles from the center of a 20-megaton burst, where numbers of casualties would have resulted due to burns and partial collapse of frame houses.[179] Rotation of rescue teams could allow exposure to higher radiation intensities, and hence earlier rescue operations, but would increase the requirement for rescue forces. If weapons were airbursted, so that little fallout contamination resulted, rescue forces could enter blast areas soon after the detonation.

(NOTE: severe upwind fallout in the blast damaged area was measured after 10 megaton surface burst MIKE in 1952, see weapon test report WT-615 and AFSWP-507. However, this upwind fallout was a fluke due to the 82-ton steel bomb "case shock" which embedded itself deep into the crater, increasing the activity on large fallout flakes around ground zero. Data from weapons with lighter casings in Castle 1954 and Redwing 1956 disproved the MIKE upwind fallout data for practical, deliverable weapons, WT-1317. MIKE upwind fallout data was given in Glasstone ENW 1957 but was replaced with Redwing upwind fallout data in Glasstone 1962, so light upwind fallout permitted rescue.)

178. U.S. Federal Civil Defense Administration, Survival in Public Shelters, 1957, at 5-9.

179. Id. at 7-8.

The Corps of Engineers analysis of requirements for rescue squads is in U.S. Army Engineer School, Extension Subcourse 321, Civil Defense and Disaster Recovery, Ft. Belvoir, Virginia (May 1958) at 3-3 to 3-4. This document states that about 25 per cent of persons surviving in blast-damaged areas will be lightly trapped and 5 per cent heavily trapped. About 2 man-hours are required to release persons lightly trapped and 20 man-hours for those heavily trapped. Trapped casualties can survive for 4 days, and rescue squads can each produce some 768 man-hours of efficient rescue work in this time. Thus in a city where 100,000 persons remained in blast areas, about 25,000 people would be lightly trapped and 5000 heavily trapped. This would require 65 light rescue squads and 130 heavy squads, each composed of 26 men with appropriate equipment. The total rescue force requirement is thus 5070 persons, or about 50 per 1000 of target area population at the time of detonation.

One promising avenue for reducing vulnerability is to put selected industries underground. The Rand Report suggests that if we had put something like twenty per cent of our manufacturing capital underground by 1970, that economy ought to be able to withstand a 20,000-megaton, 150-city attack somewhat better than our undispersed economy in 1960 could withstand a 1500-megaton, 50-city attack.[252] A 1956 study by the Corps of Engineers discussed in some detail the problems of constructing underground industrial plants. The study pointed out that some sixty per cent of American industry lay in a quadrangle from Boston to Kansas City, and that about two-thirds of existing mine sites, suitable for underground plants, also lay in this quadrangle.[253] Experience both with underground plants in Sweden and Germany and with windowless, fully air-conditioned surface plants in this country indicates that no major personnel problems are likely to arise from working underground.[254]

252. Kahn, Rand Report, op. cit. supra note 62 at 29-30 and 11.

253. U. S. Department of the Army, Corps of Engineers, Underground Plants for Industry, Washington, GPO, 1956 at 7; see too id. at 19.

254. Id. at 37-38 and 7. For discussion of an underground metal processing and fabricating plant in Norway see Skarsgaard, Olav K.," "The Largest Underground Industry in the World." The Fifteen Nations (Number 16) at 124-125.

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Mor July 13, 1979

CIVIL DEFENSE FOR THE 1980's--CURRENT ISSUES

Presidential Decision (PD) 41, September 1978, established new policies for U.S. civil defense: that it should "enhance deterrence and stability and. . . reduce the possibility that the Soviets could coerce us in times of increased tension," and "include planning for population relocation during times of international crisis." The PD 41 policies are in marked contrast to previous rationales for CD, dating from 1961, which were to the effect that the program should provide "insurance" in the unlikely event of a failure of deterrence.

President Kennedy in 1961:

> But this deterrent concept assumes rational calculations by rational men. And the history of this planet, and particularly the history of the 20th century, is sufficient to remind us of the possibilities of an irrational attack, a miscalculation, an accidental war, or a war of escalation in which the stakes by each side gradually increase to the point of maximum danger which cannot be either foreseen or deterred. It is on this basis that civil defense can be readily justifiable--as insurance for the civilian population in case of an enemy miscalculation. It is insurance we trust will never be needed--but insurance which we could never forgive ourselves for foregoing in the event of catastrophe.18/

18/President John F. Kennedy, "Urgent National Needs, A Special Message to Congress," May 25, 1961.

More light was shed on issues of credibility by a national-sample survey conducted for DCPA in late 1978, involving in-depth interviews with 1620 adult Americans.31/ The results suggest that the public remains favorable in general to civil defense, and is receptive to crisis relocation in particular:

67% believe there could be crisis circumstances under which the President might urge people to evacuate high risk areas

78% believe the U.S. should have crisis relocation plans

70% say that if the President directed relocation, they would comply. (And additional people indicate they might well leave spontaneously, before any direction to do so)

75% believe the nation's communities would be helpful to evacuees

82% believe their own communities would be helpful, if asked to host evacuees. (In fact, 73% say they'd be willing to take evacuees into their own homes)

31/Nehnevasja, Jiri, Issues of Civil Defense: Vintage 1978--Summary Results of the 1978 National Survey, University of Pittsburgh, 1979.

It is significant that on September 1-3, 1939 the British moved some 1.5 million women and children from London and a few other large cities in what was a crisis evacuation, for Britain did not declare war until September 3. (Also of interest are the facts that some 2 million additional persons spontaneously evacuated at their own initiative, and that this was unsuspected at the time by the British government.) It is also worthy of note that in Hurricane Carla, in 1961, between half and three-quarters of a million people were evacuated from Gulf Coast cities without a single fatality or a major reported accident.32/

32/Senate Committee on Banking, Housing, and Urban Affairs, Hearings, Civil Defense, 95th Congress, 2d Session (January 1979) at 51-52.

> In 1939, Hitler attacked Poland, though it appears he calculated (mistakenly) that he had good chances of achieving his objectives without triggering World War II, based upon his earlier successes. In 1941 he attacked the USSR, anticipating the destruction of Bolshevism and not, eventually, of the Third Reich.
>
> In 1941 the leaders of Japan attacked the U.S., not anticipating the defeat of the empire in 1945.

--Presidential Decision 41

At all events, the PD 41 policies lay it down clearly that U.S. civil defense should ". . . enhance deterrence and stability, and contribute to perceptions of the overall U.S./Soviet strategic balance and to crisis stability, and also reduce the possibility that the Soviets could coerce us in times of crisis."

Civil Defense and the Cuban Crisis

In a 1978 interview, Steuart L. Pittman, who was Assistant Secretary of Defense for Civil Defense in 1961 to 1964, pointed out:

> [I]t is interesting that President Kennedy personally raised the civil defense question during the Cuban crisis. He was considering conventional military action against Cuba to knock out the missile sites. I understand he was the only one of the "Committee" to raise the issue of civil defense, which tells us something. He asked whether it would be practical to evacuate Miami and other coastal cities in Florida. . . . I was called into the marathon crisis meeting and had to tell him that it would not be practical; we did not have any significant evacuation plans. . . . The President dropped the idea, but shortly after the crisis was over, his personal concern over his limited civil defense options led him to sign a memorandum directing a significant speedup in the U.S. civil defense preparations. (Emphasis added.)93/

While history seldom repeats itself exactly, it does indeed "tell us something" that in the only overt nuclear confrontation the world has

93/Sullivan, Roger J. et al, The Potential Effects of Crisis Relocation on Crisis Stability, System Planning Corporation, Arlington, Virginia, September 1978 at 152-153.

yet seen, the American President was concerned about civil defense--and that the idea of population relocation during the crisis was one of his specific concerns. Certainly it is clear that in 1962, the notion of vulnerability being stabilizing held little attraction for the Chief Executive.

There is an historical precedent for a relatively rapid buildup of CD capabilities. At the time of the 1938 Munich crisis, Britain had developed civil defense plans but had little capability for actual operations. Spurred by the belief that war had become not only not unthinkable but not unlikely, Britain mounted an intensive effort.

By the time Germany attacked Poland the next September, the British were able to evacuate 1.5 million women and children from major target cities. And by the time of the August 1940 "blitz," the CD system was able to contribute substantially to Britain's ability to "take it" and to continue the war.

Following the Munich crisis, which found Britain as unprepared in civil defense as in all other areas of defense, the working of the civil defense services was reviewed by the House of Commons during a censure debate:

> Members were in a worried and critical mood, and among the charges made it was maintained that the Government had neither policy nor plans for evacuation when the country was on the verge of war. . . . [T]here was much uneasiness in Whitehall.102/

In short, there will be no public outcry for civil defense in normal times. There will be modest political profit, if any, for an Administration proposing enhanced civil defense, or a Congress approving it; the subject is not a congenial one. But should a frightening crisis find civil defense in disarray, the people (and the Congress) would surely demand to know what had been done in "the years that the locust hath eaten."103/

Summary

The PD 41 policies provide that the U.S. civil defense program should enhance deterrence and stability, and reduce the possibility of Soviet coercion during a crisis.

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* * *

102/Titmuss, Richard M., Problems of Social Policy, HMSO, London, 1950 at 30.

103/Joel 2:25. This phrase, according to Churchill, was used by Sir Thomas Inskip in referring to the period 1931-1935: The Gathering Storm, Houghton Mifflin, Boston, 1948 at 66.

Arguments Against Civil Defense and a Rebuttal

Some of the arguments made against civil defense were parodied as follows in a piece in the Harvard Crimson in 1962:

Recommendations by the Committee for a Sane Navigational Policy:

It has been brought to our attention that certain elements among the passengers and crew favor the installation of lifeboats on this ship. These elements have advanced the excuse that such action would save lives in the event of a maritime disaster such as the ship striking an iceberg. Although we share their concern, we remain unalterably opposed to any consideration of their course of action for the following reasons:

1. This program would lull you into a false sense of security.

2. It would cause undue alarm and destroy your desire to continue your voyage in this ship.

3. It demonstrates a lack of faith in our Captain.

4. The apparent security which lifeboats offer will make our navigators reckless.

5. These proposals will distract our attention from more important things, e.g., building unsinkable ships. They may even lead our builders to false economies and the building of ships which are actually unsafe.

6. In the event of being struck by an iceberg (we will never strike first) the lifeboats would certainly sink along with the ship.

7. If they do not sink, you will only be saved for a worse fate, inevitable death on the open sea.

8. If you should be washed ashore on a desert island, you could not adapt to the hostile environment and would surely die of exposure.

9. If you should be rescued by a passing vessel, you would spend a life of remorse mourning your lost loved ones.

10. The panic caused by a collision with an iceberg would destroy all semblance of civilized human behavior. We shudder at the prospect of one man shooting another for the possession of a lifeboat.

11. Such a catastrophe is too horrible to contemplate. Anyone who does contemplate it obviously advocates it.

HISTORY OF THE SECOND WORLD WAR

Civil Defence

By

T. H. O'BRIEN

The point is of importance for students of the subject in an era in which marked 'progress' has been made in the technique of air warfare by the invention of the atomic bomb. This invention has given fresh currency to the view that 'nowadays every war is different from the one before'—which, if it were valid, would abolish any need to learn the lessons of past experience.

THE WAR OF 1914–1918 9

But in May 1917 the Germans began a series of assaults with twin-engined aircraft, called *Gothas*, which soon became severe. The daylight attack of 13th June on London by fourteen *Gothas* was the worst single attack of the war measured in casualties, which numbered 162 killed and 426 injured; 118 high explosive and incendiary bombs were dropped on the City and the East End.

10 *Ch. I: INTRODUCTION*

The Government only gave in gradually and reluctantly to demands for public warnings in London. In July 1917 a system was introduced, under the control of the Commissioner of Police, which to those accustomed to the sirens of 1939–45 may appear somewhat primitive. Warnings were distributed partly by maroons (or sound bombs) fired into the air, and partly by policemen on foot, on bicycles or in cars carrying *Take Cover* placards and blowing whistles or sounding horns.

THE WAR OF 1914–1918 11

during 1914–18 There were in all 103 bombing raids (51 by airships and 52 by aeroplanes); and about 300 tons of bombs were dropped causing 4,820 casualties, 1,413 of which were fatal.

These totals appear small; but when they are broken down into details many different pictures emerge. The two heavy raids on London of June and July 1917, for example, together caused 832 casualties (216 fatal), which amounted to 121 casualties for each ton of bombs dropped; and these casualty figures were to have much significance for the planning authorities of the future.

13 June London raid: 118 bombs, 162 killed, 426 injured.
7 July London raid: 54 killed, 190 injured

121 casualties/ton, 31 killed/ton
(Air raids by twin-engined Gothas began in May 1917)

The Committee of Imperial Defence, created in 1904

In November 1921 the Committee asked the principal Service experts to report on the problem of possible future air attack on the United Kingdom. This report, which appeared the next year, accepted the conclusions of the Air Staff about future air attack, which were briefly as follows.

France's Air Force could drop an average weight of 1,500 tons of bombs on Britain each month by using only twenty bombing days in the month and only fifty per cent of its aircraft. London, which would be an enemy's chief objective, could be bombed on the scale of about 150 tons in the first 24 hours, 110 tons in the second 24 hours, and 75 tons in each succeeding 24 hours for an indefinite period. It was to be anticipated that an enemy would put forth his maximum strength at the outset.

Page 14: on 15 May 1924, the Air Raid Precautions (ARP) Sub-Committee first met, chaired by Sir John Anderson.

The serious picture thus presented assumed its darkest tones when the Air Staff proceeded to estimate casualties. The 300 tons of bombs dropped in the 1914–18 attacks, the experts pointed out, had caused 4,820 casualties, or 16 per ton of bombs. The 832 casualties of the two big daylight attacks on London in the summer of 1917, however,

produced an average of 121 casualties per ton; and sixteen night raids on London in 1917–18 gave an average of 52 casualties per ton.[1] After weighting these figures with various factors, the experts concluded that 50 casualties (one-third of which would be fatal) per ton formed a reasonable estimate of casualties caused by air attacks of the future on densely-populated areas. For other areas this figure should be reduced in proportion to the actual density of population.

In March 1927 the committee was faced with two matters

Royal Charter incorporating the British Broadcasting Corporation, *Wireless Broadcasting*, Cmd. 2756, 1926.

The Chemical Warfare Research Department had been making experiments to determine how long persons could remain under certain conditions in a 'gas-proof' room; and had prepared a handbook, *The Medical Aspects of Chemical Warfare*, now on sale to the public.

The first of the matters just referred to was a broadcast in February by Professor Noel Baker, on 'Foreign Affairs and How They Affect Us'. This, read in cold print at a distance of twenty years, appears as an attempt to rouse the British public to realisation of the horrors of future war, and to enlist its support for the disarmament negotiations at Geneva. The Professor quoted Mr Baldwin's speech to the Classical Association in the Middle Temple hall, 'Who in Europe does not know that one more war in the West and the civilisation of the ages will fall with as great a shock as that of Rome?' He painted a picture of gas attack from the air in another war and claimed, 'all gas experts are agreed that it would be impossible to devise means to protect the civil population from this form of attack'. The Chemical Warfare Research Department emphatically disputed the accuracy both of the details of the picture and of this general statement. They considered it unfortunate that statements of this nature should have been broadcast to the public, particularly after the Cabinet's decision that the time was not ripe for education of the public in defensive measures.

The committee discussed whether to draw the B.B.C.'s attention to this talk. The Corporation, only a few months old, was then prohibited by the Postmaster-General's instructions from broadcasting 'matter on topics of political, religious or industrial controversy'; but the Post Office representative pointed out this did not mean that his Department was prepared to undertake censoring programmes. The committee, not wishing to incur the obligation to approve in advance all proposed broadcasts relating to their field of study, decided to take no action with respect to the talk in question.

Gas was the risk most prominently associated in the public mind with future air attack, as was demonstrated a few weeks before the school opened by British reaction to Italy's use of mustard and other gases against Abyssinia.[4]

[4] According to the *Annual Register, 1936* (p. 27), 'feeling in England could hardly contain itself when the Italians were reported to be using poison gas against both soldiers and civilians'.

A final matter which concerned gas-masks belongs perhaps more properly to the topic of public reactions to A.R.P. Early in 1937 some scientific workers at Cambridge University, who described themselves as the 'Cambridge Scientists' Anti-War Group' and their function as that of acting as 'a technical and advisory body to national and international peace movements', published a book attacking the Government's A.R.P. plans.[1] This body had studied the official advice about the 'gas-proofing' of rooms, the civilian mask, and extinguishing incendiary bombs, and then conducted some experiments. It claimed to have shown that the measures officially proposed were ineffective or inadequate, and implied that these constituted deception of the public.

It has been noticed that as 1937 opened the Government was taking steps to make A.R.P. plans more widely known to the public;[2] and this deliberate challenge found a sympathetic echo in various quarters, and caused it some concern. Questions about the Cambridge experiments were asked in Parliament, for example on the occasion of the announcement of the new Wardens' Service; sections of the Press began a critical campaign, and questions were put to officials trying to build up A.R.P. services over the country. The Government's reply was that the experiments were academic (in the sense of removed from reality), and based on fallacious assumptions about the conditions likely to be met in actual warfare.[3] In spite of pressure the authorities refused to engage in technical controversy with the scientists in question and within a few months the agitation subsided. At the close of the year, however, a report on the official experiments (in supervision of which the Chemical Defence Committee had been helped by eminent scientists not in Government employment) was circulated to local authorities and otherwise made public.

[1] *The Protection of the Public from Aerial Attack* (Left Book Club Topical Book, Victor Gollancz Ltd, 1937.)

[2] p. 71.

[3] H. of C. Deb., Vol. 320, Col. 1348, 18th February 1937.

A demonstration of how to deal with the light incendiary bomb had been included in the Anti-Gas School curriculum in November 1936; and in February 1937 the Home Office Fire Adviser staged a demonstration at Barnes at which bombs were successfully controlled and fires extinguished by teams of girls with only short training. At an exercise held later at Southampton a group of air raid wardens carried out this function with such success that the Department concluded it must aim to train all householders in the handling of incendiary bombs.

Air Staff had raised their estimate of the weight of bombs which an enemy (now Germany) might drop on Britain during the first stages of an attack from 150 tons *per diem* to no less than 600 tons. The committee proceeded, as their predecessor of 1924 had done, to question the experts and then to accept their hypothesis.[1] The estimate of over 600 tons of bombs *per diem* during the first few weeks (which took account of Britain's various potential forms of counter-offensive) also embraced the possibility of a special bombing effort on the part of the enemy in the first 24 hours which might amount to 3,500 tons. Consideration had to be taken not only of this greatly increased weight of attack but of new methods of attack for which past experience afforded no precedents. The measure offered by the accepted air raid casualty figure of 1914–18 (50 per ton of bombs, 17 of which were killed and 33 wounded) was subject to the *caveat* that modern bombs were more effective. The committee pointed out that an arithmetical computation on this basis for the scale of attack at 600 tons *per diem* would indicate casualties of the order of 200,000 a week, of which 66,000 would be killed.

[1] The new estimated scale of attack had been referred to the Home Defence Committee, and was not approved by the Committee of Imperial Defence until 28th October 1937.

The 25 million civilian gas-masks accumulated by the opening of 1938 were, from various points of view, one of the most tangible assets of the A.R.P. Service.

The invention of a practical household shelter—to be quickly known as the 'Anderson'—had transformed the possibilities hitherto envisaged for protection of homes against air attack. The Government had undertaken to supply these shelters, as well as steel fittings for strengthening basements, free to some 2½ million families.

The 'Anderson' had originally been conceived as a shelter to be erected inside the average small working-class home. But the experts soon discarded this idea as open to various objections, including the probability that occupants would be trapped by the fall of their house and killed by fire or escaping coal-gas. During Munich householders had been advised to dig trenches in their yards or gardens, and now, by an extension of this plan, the 'Anderson' was designed as an outdoor or surface shelter. It consisted of fourteen corrugated steel sheets weighing, with other components, about 8 cwt. A corrugated steel hood, curved for greater strength, would be sunk some two feet in the ground and covered with earth or sandbags.

196 *Ch. V: THE NEW ARM OF CIVIL DEFENCE*

The programme for manufacture and distribution by the end of 1939–40 of 2½ million 'Andersons' to protect about 10 million citizens was being steadily carried through.

SHELTERS 371

householders in May in the form of a booklet, *Your Home as an Air Raid Shelter.*[1] This stated that an ordinary soundly-built house would offer very substantial protection; and it gave those unable to build some form of shelter much detailed guidance on the preparation of refuge rooms, the protection of windows and so on.

[1] H.S.C. 98/40, 22nd May 1940.

416 *Ch. X: THE TIDES OF BATTLE*

16 April 1941: heaviest London air raid of WWII:

On the night of 16th-17th some 450 aircraft made the heaviest raid so far on the capital, dropping 446 tons of high explosive and 150 tons of incendiaries and causing more casualties—about 1,180 killed and 2,230 badly injured—than in any previous attack.[1] Over 2,250 fires were started; and the centre and south of the metropolis bore the brunt of the attack.

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[1] German records show the much higher figures of 685 aircraft, 890 tons of H.E. and 4,200 incendiary canisters dropped. This attack proved the worst on London of the war in terms of weight of bombs dropped, casualties inflicted and the number of fires caused.

438 *Ch. X: THE TIDES OF BATTLE* **1943:**

These occasions apart, the attack was predominantly of the tip and run or—as it was sometimes called—'the scalded cat' variety. The worst single incident of the year took place on 3rd March at Bethnal Green Tube shelter when, ironically enough, no attack was in progress on this particular area. A night attack of moderate proportions was being made on London, and warnings had sounded. A woman among the crowd entering this shelter, encumbered by a baby and a bundle, fell, causing those pressing behind her to tumble in a heap and the death by suffocation of no less than 178 persons. **3 March 1943**

508 *Ch. XII: SHELTERS*

In London a periodical count was made of shelterers, usually once a month; but this took place on a single night which was not necessarily typical. In addition, the population was continually fluctuating owing to evacuation, the call-up to the Forces and war damage. The first shelter census in Metropolitan London, taken early in November 1940, showed that 9 per cent. of the estimated population spent the night in public shelters, 4 per cent. in the Tubes and 27 per cent. in household shelters—in all, only 40 per cent. in any kinds of official shelter. In September and October this proportion was probably a good deal higher. Later, as the London public became accustomed to raids, the figures dropped.

Experience of raids also led to the introduction of an entirely new type of household shelter. 'Andersons', though structurally satisfactory, had not originally been intended for sleeping and became in many cases unfit for winter occupation. Domestic surface shelters were very cramped when used for sleeping and were in some places not popular, and strengthened domestic basements had been neither very successful nor widely used. After night raiding had ceased to be a novelty, many people preferred to stay in their houses rather than to go out of doors even to their own domestic shelters. The 'Anderson', it will be recalled, had at first been envisaged as an indoor shelter. Since many people were now determined to remain in their homes, it had become necessary to introduce some indoor shelter which might reduce the risk of injury from falling masonry and furniture. The fact that many who had hitherto sheltered under their staircases or furniture had been rescued unhurt from the wreckage of houses suggested that extra protection might be given by a light structure on the ground floor.

By the end of 1940 two designs had been produced. The first, later known as the 'Morrison' shelter, had a rectangular steel framework 6 ft. 6 in. long, 4 ft. wide and about 2 ft. 9 in. high. The sides were filled in with wire mesh, the bottom consisted of a steel mattress and the top was made of steel plate an eighth of an inch thick, fastened to the framework by bolts strong enough to withstand a heavy swinging blow. The shelter, which could be used as a table in the daytime, could accommodate two adults and either two young children or one older child, lying down. Experiments showed that it would carry the debris produced by the collapse of two higher floors.

The Prime Minister showed great interest in these shelters the first of which, in fact, were erected in No. 10 Downing Street.[2] In January 1941 the Cabinet approved the manufacture of 400,000, providing protection for perhaps 1,200,000 people.[3]

In February contracts had been placed for 270,000 shelters, and another order for the same number was placed in April (thus exceeding the 400,000 originally approved). Two further orders for 270,000 were placed at the end of July and the end of September.

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[1] Instructions were given in a pamphlet, *How to put up your Morrison shelter*, on sale to the public.

[2] One with a flat top and one with a curved top were erected in No. 10 Downing Street. The Prime Minister was at first inclined to favour the curved design but he afterwards recognised the advantages of the flat top, which would allow the shelter to be used as a table, and gave his approval to both designs.

[3] It was estimated that each 'Morrison' would use over 3 cwt. of steel, and that about 65,000 tons would be needed for the 400,000 shelters. This proved to be an underestimate since the table shelter, as finally designed, actually weighed 4.43 cwt.

In June a revised version of *Your Home as an Air Raid Shelter* was issued with the title *Shelter at Home.* This included information about three types of shelter which could be put inside refuge rooms—the 'Morrison', a commercially made steel shelter, and a timber-framed structure designed by the Ministry of Home Security.

It was assumed that to be effective in attacks by pilotless aircraft or long-range rockets, shelters would have to be easily accessible. Yet a review of London shelter in the summer of 1943 had shown that large numbers still had no domestic shelter, and that many thousands would be unable to reach a public shelter quickly. Though the obvious solution to the problem was the 'Morrison', production of these had stopped twelve months before; and in order to build up a reserve issue had been discontinued in various areas, including London. At the beginning of October it was decided that another 100,000 'Morrisons' should be manufactured and that the reserves held in Scotland, the North of England, the Midlands and North Wales should be moved to the vicinity of London and to the Reading and Tunbridge Wells Regions, from where they could, if necessary, be used to supply London.

Large-scale redistribution of 'Morrisons' and the procurement of new ones called for a substantial administrative effort. Nonetheless, most reserves were transferred during the autumn, and by the end of January 1944 some 12,000 had deen distributed to London householders. At the beginning of this year, however, preparations for the Allied invasion of Europe began to choke the railways with more important traffic, and it became impossible to transport new shelters from manufacturers in the north of England. This difficulty, combined with delays in the production of spanners and nuts, meant that no new shelters could be delivered before late February or early March, when it was expected that the V-weapon attacks would have begun. Arrangements were made for some to be shipped coastwise to London; but in mid-February the contract for the remaining 'Morrisons' (about 20,000) was cancelled. **V2 THREAT:**

On 11th September the War Cabinet considered the need for a revival of the plan (known as the 'black move') to evacuate a proportion of the staffs of Government Departments from London. The numbers now involved in such an exodus of the war-expanded Departments would be high, and difficulties of communications, transport, accomodation and billeting again seemed overwhelming; it was, therefore, agreed that the more practical course would be to devise measures such as 'citadel' accommodation to enable essential work to continue in London. The production of the further 100,000 'Morrison' shelters and the work on the reinforcement of street shelters proposed by the Home Secretary were also authorised.

As far as shelter policy was concerned, orders had been placed in September 1943 for an additional 100,000 indoor table shelters and existing stocks were moved into the areas of probable attack. Difficulties of manufacture and transport had led to poor deliveries of 'Morrisons', and it seemed unlikely that more than half of the additional shelters ordered would be available by the time attacks were likely to begin. As the remainder would probably arrive too late to be of any use, contracts for the shelters were to be reduced by about 25,000. On the question of deep Tube shelters it had been agreed earlier that priority in the allocation of space would have to be given to the essential machinery of government. The Ministry of Works worked out a plan to shelter those government staffs not already provided for in the strengthened basements of their own steel-framed buildings. All shelter plans, the reader will recall, were given valuable impetus by the resurgence of 'conventional' attack on London and the south in the 'Little Blitz' of early 1944.

Flying glass was a special danger and people were warned to take cover on the sound of a bomb diving or the engine stopping, and later on the sounding of imminent danger warnings. The vast damage to houses inevitably caused great domestic upheavals. To begin with there was a definite decline in production in London, due to an increase in the rate of absenteeism, to loss of time in actual working hours through workers taking shelter and to lowered efficiency through loss of sleep and anxiety. The extension of the industrial alarm system and the increase in the labour force repairing damaged property, however, soon reduced these early signs of disturbance. Within a few weeks evacuees were returning to London, shelters were less full and most people were going about their normal tasks as usual.

For the civil defence services the new weapon demanded new tactics. In many ways these attacks were much easier to contend with than ordinary bombing. Firstly, most of the incidents were isolated, so that services could be directed in strength to the affected area without constant competing demands on the personnel at every turn. Secondly, the fall of the bombs could be spotted within a matter of seconds by high-placed observation posts either by night or by day, so that rescue and first aid squads could be on the spot very quickly. Thirdly, the penetrative power of this weapon was slight so that incidents rarely involved the complications of broken gas, electricity or water mains, and there was also little tendency for fires to break out. On the other hand the bombs could fall at any time in crowded thoroughfares; the proportion of casualties in the streets was much higher than ever before while the proportion of trapped casualties was lower. At night time, since there were no German eyes above, the use of artificial light was less restricted and searchlights could be used for rescue work.

APPENDIX IV

Major night attacks on United Kingdom cities and towns from 7th September, 1940 to 16th May, 1941

Target Area	*Number of Major Attacks*[1]	*Tonnages of H.E. Aimed*
London	71	18,291
Liverpool-Birkenhead	8	1,957
Birmingham	8	1,852
Glasgow-Clydeside	5	1,329
Plymouth-Devonport	8	1,228
Bristol-Avonmouth	6	919
Coventry	2	818
Portsmouth	3	687
Southampton	4	647
Hull	3	593
Manchester	3	578
Belfast	2	440
Sheffield	1	355
Newcastle-Tyneside	1	152
Nottingham	1	137
Cardiff	1	115

[1] The enemy's definition of a 'major attack', i.e. one in which 100 tons or more of high-explosive bombs were successfully aimed at the target, has been adopted for this table.

Issued for the Ministry of Home Security
by the Ministry of Information

FRONT LINE

1940-41

The Official Story of the
CIVIL DEFENCE
of Britain

1942
London: His Majesty's Stationery Office

So far was all this from panic that it took three months for the population of the twenty-eight central boroughs to drop by about 25 per cent. from a little over 3,000,000 (the figure before heavy bombing began) to 2,280,000 at the end of November. In a group of the most heavily bombed eastern boroughs the pre-war population of 800,000 had fallen to 582,000 before the blitz began ; for four months it had dropped steadily to 444,000 ; by 31st December a fall of 23 per cent. These figures do not spell panic, and a further substantial fall in 1941, after continuous heavy raiding had ceased, completes the evidence that those who went did so in cold blood, for practical reasons as valid for their hard-pressed city as for their private selves.

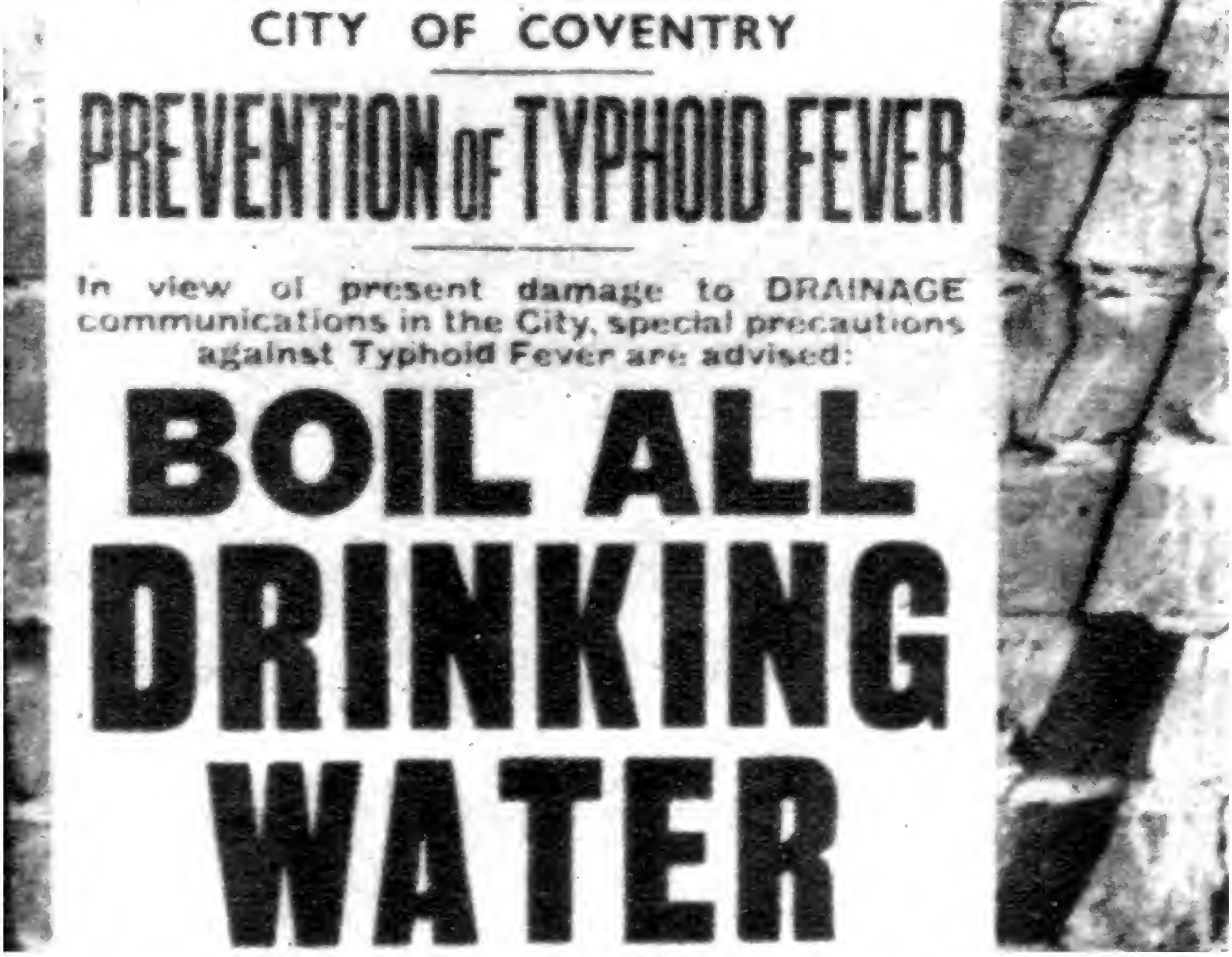
But what did all this mean to the average Londoner ? In November, inner London (the county) contained some 3,200,000 people. Not more than 300,000 of these were in public shelter of any kind, half of that number at most in those larger shelters on which the limelight shone so exclusively. Nor is this all ; in domestic shelter (Andersons, small brick shelters and private reinforced basements) there were no more than

1,150,000 people. Thus of every hundred Londoners living in the central urban areas, nine were in public shelter (of whom possibly four were in "big" shelters), 27 in private shelter, and 64 in their own beds—possibly moved to the ground floor—or else on duty. Particular big shelters, and for a few nights the tubes, were overcrowded, but there was public shelter for twice the number who made use of it. In outer London, with a population of some 4,600,000, there were in November 4 per cent. in public shelter, 26 per cent. in domestic shelter, and 70 per cent. at home or on duty.

In the last great war there had been outbursts of hate against the distant enemy, and shops with German names had been wrecked. This time the citizens did not stop for such things. After the first shock of realisation they found no more need for direct recrimination than does the soldier. Like him, they got on with the job and waited their chance. Neither in this nor in any other way was there a sign of instability; no panic running for shelter, no white faces in the streets (though plenty of taut, grim ones), no nerve disease. In all London, the month of October saw but twenty-three neurotics admitted to hospital. The mind-doctors had rather fewer patients than usual.

BLOCKED ROADS. The morning of 12th May: each raid sets the police still another traffic problem.

ENORMOUS CRATERS. At the Bank, where the road collapsed into the subway beneath. A temporary bridge was thrown right across it.


CITY OF COVENTRY
PREVENTION OF TYPHOID FEVER
In view of present damage to DRAINAGE communications in the City, special precautions against Typhoid Fever are advised:
BOIL ALL DRINKING WATER

A PENGUIN SPECIAL

THE PSYCHOLOGY OF FEAR AND COURAGE

BY
EDWARD GLOVER

(Published for Blitz air raids in 1940)

PENGUIN BOOKS
HARMONDSWORTH MIDDLESEX ENGLAND
41 EAST 28TH STREET NEW YORK U.S.A.

Real knowledge, for example, is one of the best antidotes to unreal fear. *Useful action* is also an excellent preventive, and *vigorous preparation to meet real danger* will enormously reduce unreal fear. The strength of a common purpose will do the rest. Knowledge, a common purpose, and preparedness for action. These are the remedies for faintness of heart in the face of danger.

22

Now as to preparation. You may recall that when Napoleon was asked how he was always able to give an instant decision in a crisis, he replied: "Because I constantly prepare every detail in advance." Here is a discipline you can readily cultivate. Always make a point of knowing beforehand *exactly* what you are going to do in an air raid; whether you find yourself in house, street, train, bus or shelter. Have it word perfect.

23

A stray crowd packed into a cinema is likely to panic at the cry of "Fire." There are no common bonds between the people concerned; and there are no leaders. Each one is for himself.

34

Already we have the advantage that we are fighting not only for our lives and homes but for the immemorial cause of human liberty. But that is not enough. Provided we are united with our leaders in a common effort, real danger will never sap our morale. The greatest danger to our morale is unreal fear.

36

A. R. P.

(Air Raid Precautions)

by

J. B. S. HALDANE, F.R.S.

(Co-inventor of 1915 gas masks)

SEPTEMBER
1938

LONDON

VICTOR GOLLANCZ LTD

1938

keyholes and cracks in the wall or between the floor-boards are to be filled with putty or sodden newspaper.

The windows must be specially protected against breakage by blast or splinters.

(Plastic sheets and duct tape for broken windows)

How far are these precautions effective? In 1937 a committee of the Cambridge Scientists' Anti-War Group published a book[1] in which it was stated that no ordinary room is anywhere near gas-proof.

[1] *The Protection of the Public from Aerial Attack.*

Error of Cambridge Scientists' Anti War Group:

The real criticism is as follows. It is unlikely that there would be a lethal concentration of gas out of doors for a long period. The wind carries gas away, and in cities there are vertical air currents even in calm weather. If many tons of bombs could be dropped in the same small area either at once or in succession this would not be so. But given any sort of defence bombs will be dropped more or less at random.

Suppose we had out of doors during 10 minutes a phosgene concentration of one part in 10,000, which would be fatal in a few breaths to people in the street, the concentration inside would never rise as high as $\frac{1}{15}$ of this value[1] if the leakage time were $2\frac{1}{2}$ hours, which is rather low. (Hence protection factor = 15)

[1] Since 10 minutes is $\frac{1}{15}$ of $2\frac{1}{2}$ hours.

Many of the questions which are asked concerning Air Raid Precautions are unanswerable in the form in which they are put. If I am asked "Does any gas mask give complete protection against phosgene" the only literally true answer is "No." One could not live in a room full of pure phosgene in any of them. And one would be killed if a hundred-pound phosgene bomb burst in the room, even when wearing the very best mask. But one would be safe in a phosgene concentration of one part per thousand, of which a single breath would probably kill an unprotected man. Hence in practice such a mask is a very nearly complete protection.

1. NON-PERSISTENT GASES, such as phosgene. They can be dropped in bombs which burst, and suddenly let loose a cloud of gas, which is poisonous when breathed, but which gradually disperses. If there is a wind the dispersal is very quick; in calm, and especially in foggy weather, it is much slower. These gases can penetrate into houses, but very slowly. So even in a badly-constructed house one is enormously safer than in the open air. Even the cheapest type of gas mask, *provided it fits properly and is put on at once*, gives good protection against them (see Chapter IV).

2. PERSISTENT GASES, such as mustard gas. Mustard gas is the vapour of an oily liquid, which I shall call mustard liquid. So far as I know this has not been dropped from aeroplanes in bombs on any great scale. It was used very effectively by the Italians in Abyssinia, who sprayed it in a sort of rain from special sprayers attached to the wings of low-flying aeroplanes.

If the mustard liquid could be sprayed evenly, things would be far more serious. All the outside air of a large town would be poisonous for several days. But this would only be possible if the spraying aeroplanes could fly to and fro over the town in formation, and at a height of not more than 300 feet or so. A fine rain of mustard liquid would probably evaporate on its way to the ground, or blow away, if it were let loose several thousand feet up in the air. Spraying from low-flying aeroplanes was possible in Abyssinia because the Abyssinians had no anti-aircraft guns and no defensive aeroplanes. It would probably not be possible in Britain.

THE HAMBURG DISASTER. Fantastic nonsense has been talked about the possible effects of gas bombs on a town. For example, Lord Halsbury said that a single gas bomb dropped in Piccadilly Circus would kill everyone between the Thames and Regent's Park. Fortunately, although no gas bombs have been dropped in towns in war-time, there are recorded facts[1] which give us an idea of what their effect would be. On Sunday, May 20th, 1928, at about 4.15 p.m., a tank containing 11 tons of phosgene burst in the dock area of Hamburg.

Casualties occurred up to six miles away. In all 300 people were made ill enough to be taken to hospital, and of these ten died. About fifty of the rest were seriously ill. These casualties are remarkably small.

[1] Hegler, *Deutsche Medizinische Wochenschrift*, 1928, p. 1551.

WHY GAS WAS NOT USED IN SPAIN

In view of the terrible stories as to the effects of gas, many people are surprised that it has not been used in Spain. First, why was it not used against the loyalist army? Secondly, why was it not used against towns? The soldiers had respirators after about February 1937, but were not well trained in their use, and often lost them. Very few civilians had any respirators at all.

Gas was not used in the field for several reasons. The main reason is that the number of men and guns per mile was far less than on the fronts in the Great War. Gas is effective if you have a great deal of it,

but the amount needed is enormous. Thus during the night of March 10-11th, 1918, the Germans fired about 150,000 mustard-gas shells into an area of some twenty square miles south-west of Cambrai. If most of the air in a large area is poisoned the effects are serious. But if a few gas shells are fired or a few cylinders let off, the gas soon scatters and ceases to be poisonous, and a man can often run to a gas-free place, even without a mask, before he is poisoned.

Gas was not used against the towns for this reason, and for another, which is very important. Gas only leaks quite slowly into houses, particularly if there are no fires to make a draught, and draw in outside air; and there is very little fuel in loyal Spain.

PANIC

Panic can be a direct cause of death. If too many people crowd into a shelter, especially one with narrow stairs leading to it, they may easily be crushed to death. In January 1918 fourteen people were killed in this way at Bishopsgate Station in London, and sixty-six were killed in a panic in one of the Paris Underground stations as the result of a false gas alarm.

(Bishopsgate Station incident: 28 January 1918)

BACTERIA AND OTHER MICROBES

It is possible that these will be used in some kind of spray or dust. The difficulty is a technical one. It is easy to disperse many solids as smoke. But this needs heat, and cooked bacteria are harmless. Many

bacteria are killed even by drying. And once bacteria are on the ground they generally stay there. Possibly pneumonic plague or some other air-borne disease might be started by a dust-bomb. Cholera bacilli might be dropped in a reservoir. But they would probably be stopped by filters, and even without this would be likely to die before they reached the houses.

A million fleas weigh very little, and could easily be dropped. In theory they could be infected with plague. In practice this would need a staff of hundreds of trained bacteriologists, and huge laboratories. So with other possible means of infection. Some may very well be tried, if only to create a panic, but I would sooner face bacteria than bombs.

248 A.R.P.

Certain pacifist writers are severely to blame for our present terror of air raids. They have given quite exaggerated accounts of what is likely to happen.

250 A.R.P.

So long as civilian populations are unprotected, criminal States will continue to murder the citizens of their weaker neighbours and to blackmail the stronger.

POISONOUS GASES AND SMOKES 261

PHYSICAL PROPERTIES OF A GAS-CLOUD. Every student of chemistry learns that a heavy gas such as chlorine can be poured from one vessel into another almost like water, whilst a light gas such as hydrogen rapidly rises. Now all the poisonous gases and vapours used in war are heavier than air, so it is thought that they would inevitably flood cellars and underground shelters, and that on the first floor of a house one would not be safe.

262 A.R.P.

But within a short time it would be mixed with many times its volume of air. Now air containing one part in 10,000 of phosgene is extremely poisonous. But its density exceeds that of air by only one part in 4,000.

GAS-MASKS, AND GAS-PROOF BAGS FOR BABIES

THE EARLIEST GAS-MASKS made in 1915, relied on chemical means to stop chlorine, which was the first gas used. A cloth soaked with sodium phenate or various other compounds will stop chlorine on its way through. But it would not stop carbon monoxide, mustard gas, or many other gases. The terrible prospect arose that it would be necessary to devise a new chemical to stop each new gas. There would be a continual series of surprise attacks with different gases, each successful until a remedy was found, and each involving the death of thousands of men.

It is a most fortunate fact that the majority of vapours can be removed from air, not by chemical combination, but by a process called adsorption, which is non-specific. For example lime will stop an acid gas such as carbon dioxide, and woollen cloth soaked in acid will stop an alkaline gas such as ammonia. No single chemical will combine with both.

But charcoal, silica, and various other substances, when properly prepared, will take up vapours of different chemical types. The molecules form a very thin liquid layer on the surface of the adsorbent, as indeed they do on glass or metals. But charcoal is full of pores and has an enormous surface per unit of weight; so it can take up a great deal of gas.

The main characteristic in a vapour which renders it adsorbable is that it should be the vapour of a liquid with a high boiling point. Thus carbon monoxide boils at $-190°$ C, and is hardly adsorbed at all. Phosgene boils at 8° C and is fairly easily adsorbed. Mustard gas boils at 217° C and is very easily adsorbed indeed. This has a lucky consequence. It is quite sure that there are no unknown poisonous gases with a boiling point as low as that of carbon monoxide. For only a substance with very small molecules can have so low a boiling point. And chemists have made all the possible types of very small molecules. It is unlikely that there are any unknown poisonous gases with as low a boiling point as phosgene, though it is just possible. But if there are they will probably be stopped by charcoal. There may very possibly be some vapours of high boiling point more poisonous than mustard gas. But if so I am prepared to bet a thousand to one that charcoal will stop them all.

AD 408 094

FINAL REPORT

11 March 1963

Recovery and Decontamination Measures after Biological and Chemical Attack

This report has been reviewed in the Office of Civil Defense and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Office of Civil Defense.

Contract OCD-OS-62-183

Prepared for
Office of Civil Defense
Department of Defense

by

Science Communication, Inc.
1079 Wisconsin Avenue, N.W.
Washington 7, D. C.

To plan for countermeasures against any weapons one must understand the problem —the nature, the potentials, and the limitations. This research project and the resultant final report were intended to bring together current information most applicable to civil defense. It was particularly intended for those who are responsible for planning preparatory, reclamation and countermeasures effort to minimize the damage from a BW/CW attack.

William J. Lacy
Project Coordinator
Postattack Research

Decontaminants

An important class of decontaminants comprises the common substances or natural influences such as time, air, earth, water, and fire.

Natural Effects

Biological agents are living organisms and tend to die off with time unless they are in a favorable environment with moisture, food, warmth, and other factors necessary for their survival. In addition, most biological organisms are very sensitive to the conditions of temperature and humidity -- and, particularly to the ultra-violet portion of sunlight. Adverse exposure to the elements -- air, sunlight, high temperature, low humidity -- is effective, in fact, against all biological agents except the spore forms of bacterial organisms.

It is generally assumed that in the vegetative form bacteria (as contrasted to the spore form) can persist for less than two hours during daytime and about eighteen hours at night. Since these short-lived bacteria are the most probable agents, outdoor decontamination is usually not called for unless the agent has been identified, either by laboratory tests or by the character of the disease, as one which forms spores or is otherwise known to be persistent.

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Field Purification of Water Contaminated by G Agents. Chemical Corps Medical Division Report No. 220, 1949. AD 212 449.

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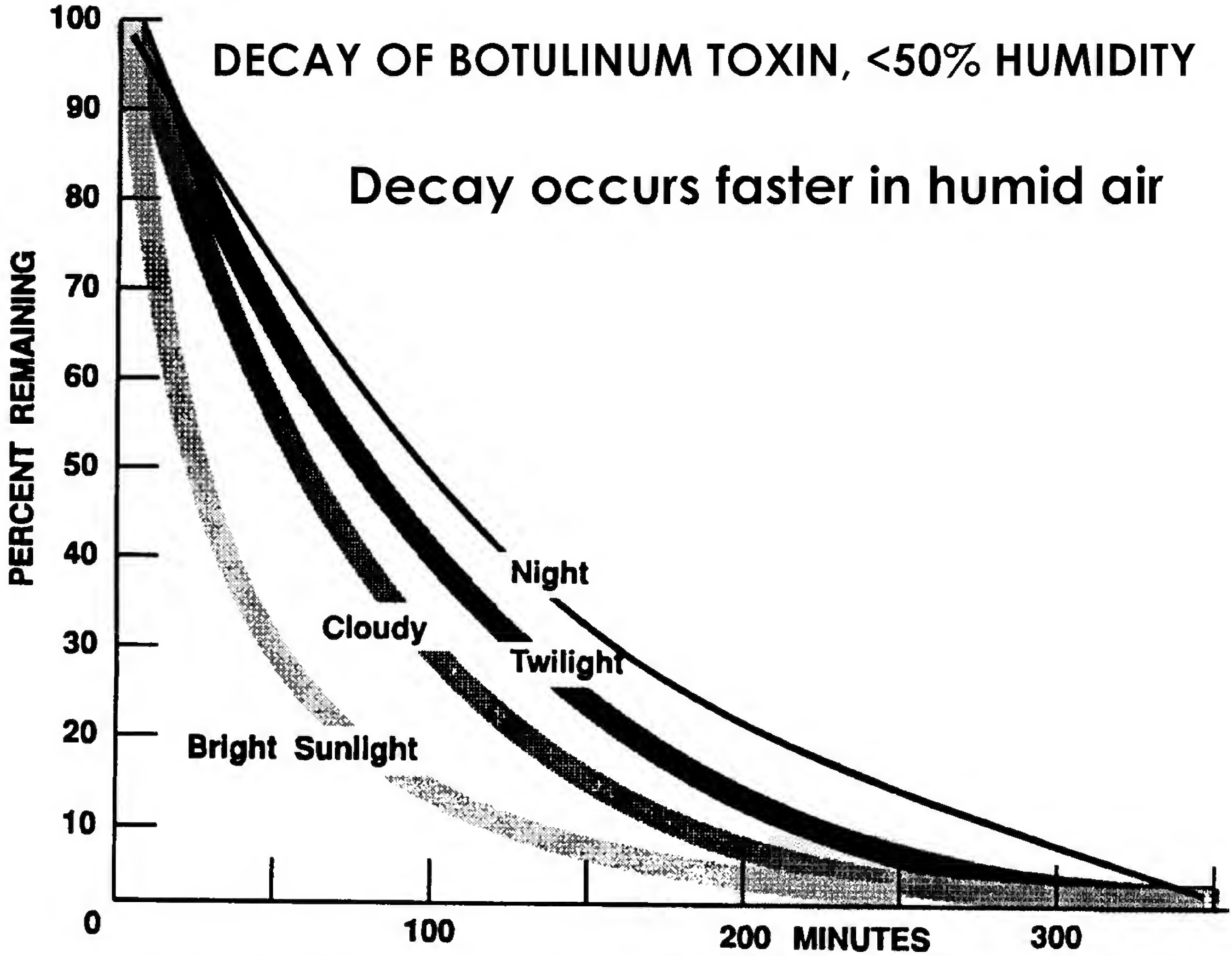
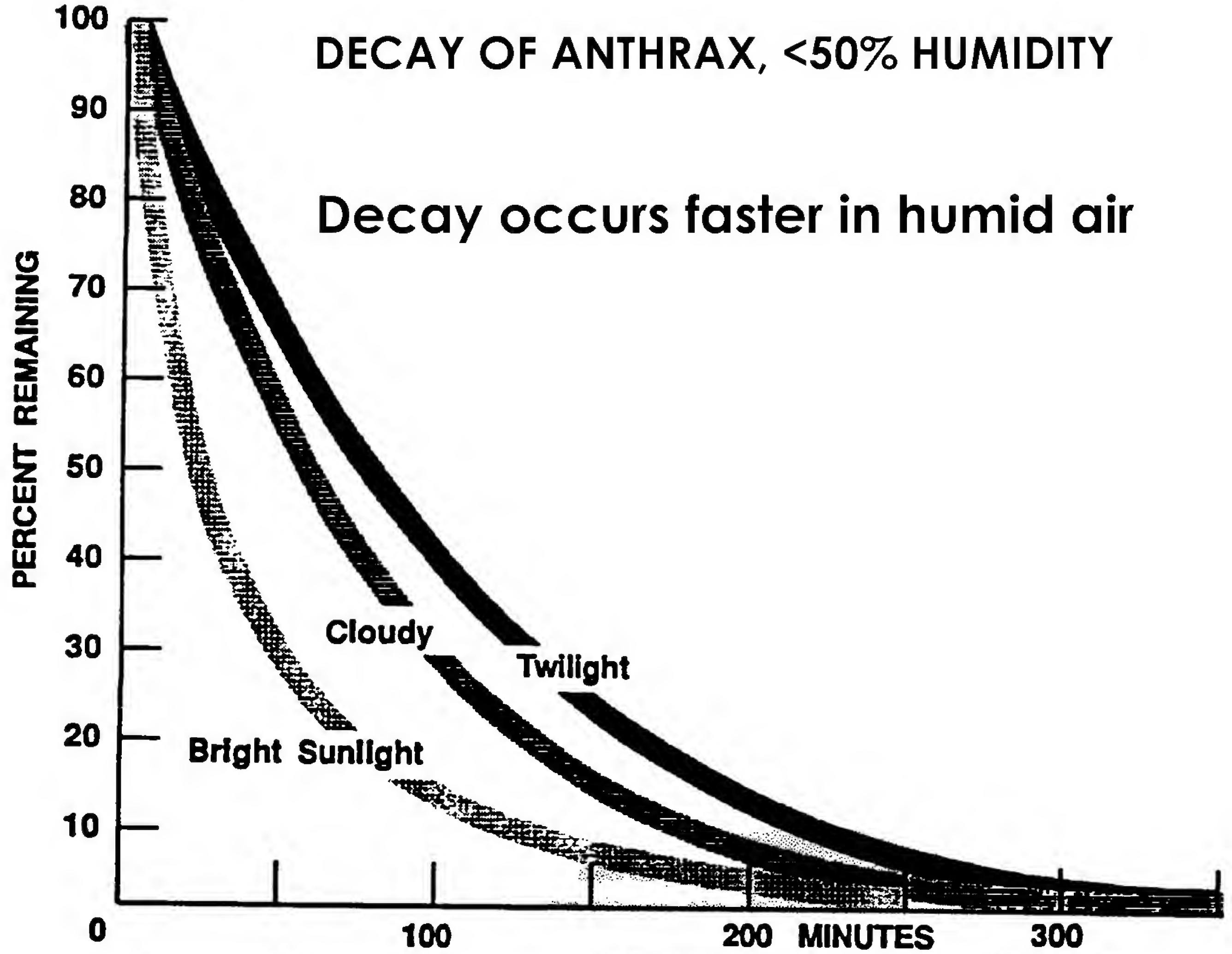


U.S. Army Field Manual FM 3-3 (1992), Fig. B-3.



U.S. Army Field Manual FM 3-3 (1992), Fig. B-1.

Chemical and biological contamination avoidance, FM 3-3 (1992)

10 grams/square meter

TABLE 1-2. Chemical Agent Persistency in Hours on CARC Painted Surfaces.

Temperature		GA/ GF[1]	GB[2,3]	GD[2,3]	HD[1]	VX[2,3]
C°	F°					
-30	-22	*	110.34	436.69	**	***
-20	-4	*	45.26	145.63	**	***
-10	14	*	20.09	54.11	**	***
0	32	*	9.44	22.07	**	***
10	50	1.42	4.70	9.78	12	1776
20	68	0.71	2.45	4.64	6.33	634
30	86	0.33	1.35	2.36	2.8	241
40	104	0.25	0.76	1.25	2	102
50	122	0.25	0.44	0.70	1	44
55	131	0.25	0.34	0.51	1	25

NOTE

1 For grassy terrain multiply the number in the chart by 0.4.

2 For grassy terrain multiply the number in the chart by 1.75.

3 For sandy terrain multiply the number in the chart by 4.5.

* Agent persistency time is less than 1 hour.

** Agent is in a frozen state and will not evaporate or decay.

*** Agent persistency time exceeds 2,000 hours.

COMPARATIVE VOLATILITY OF CHEMICAL WARFARE AGENTS

Agent	Volatility (mg/m^3) at 25°C
Hydrogen cyanide (HCN)	1,000,000
Sarin (GB)	22,000
Soman (GD)	3,900
Sulfur mustard	900
Tabun (GA)	610
Cyclosarin (GF)	580
VX	10
VR ("Russian VX")	9

Data source: US Departments of the Army, Navy, and Air Force. *Potential Military Chemical/Biological Agents and Compounds*. Washington, DC: Headquarters, DA, DN, DAF; December 12, 1990. Field Manual 3-9. Naval Facility Command P-467. Air Force Regulation 355-7.

SIGNS AND SYMPTOMS REPORTED BY TOKYO HOSPITAL WORKERS TREATING VICTIMS OF SARIN SUBWAY ATTACKS*

Symptom	Number/percentage of the 15 physicians who treated patients at UH		Number/percentage of 472 care providers reporting symptoms at SLI	
Dim vision	11	73%	66	14%
Rhinorrhea	8	53%	No information	
Dyspnea (chest tightness)	4	27%	25	5.3%
Cough	2	13%	No information	
Headache	No information		52	11%
Throat pain	No information		39	8.3%
Nausea	No information		14	3.0%
Dizziness	No information		12	2.5%
Nose pain	No information		6	1.9%

*Data reflect reported survey of self-reported symptomatology of physicians at the University Hospital of Metropolitan Japan emergency department and all hospital workers at Saint Luke's International Hospital exposed to sarin vapors from victims of the Tokyo subway attack.

SLI: Saint Luke's International Hospital

UH: University Hospital

Data sources: (1) Nozaki H, Hori S, Shinozawa Y, et al. Secondary exposure of medical staff to sarin vapor in the emergency room. *Intensive Care Med*. 1995;21:1032-1035. (2) Okumura T, Suzuki K, Fukuda A, et al. The Tokyo subway sarin attack: disaster management, Part 1: community emergency response. *Acad Emerg Med.* 1998;5:613-617. (3) Okumura T, Suzuki K, Fukuda A, et al. The Tokyo subway sarin attack: disaster management, Part 2: Hospital response. *Acad Emerg Med.* 1998;5:618-624.

Medical Aspects of Chemical Warfare (2008) **TABLE 16-3**

TABLE 21-3

MANAGEMENT OF MILD TO MODERATE NERVE AGENT EXPOSURES

		Management			
		Antidotes*		Benzodiazepines (if neurological signs)	
Nerve Agents	Symptoms	Age	Dose	Age	Dose
• Tabun • Sarin • Cyclosarin • Soman • VX	• Localized sweating • Muscle fasciculations • Nausea • Vomiting • Weakness/floppiness • Dyspnea • Constricted pupils and blurred vision • Rhinorrhea • Excessive tears • Excessive salivation • Chest tightness • Stomach cramps • Tachycardia or bradycardia	Neonates and infants up to 6 months old	**Atropine** 0.05 mg/kg IM/IV/IO to max 4 mg or 0.25 mg AtroPen† and **2-PAM** 15 mg/kg IM or IV slowly to max 2 g/hr	Neonates	**Diazepam** 0.1–0.3 mg/kg/dose IV to a max dose of 2 mg, or **Lorazepam** 0.05 mg/kg slow IV
		Young children (6 months old–4 yrs old)	**Atropine** 0.05 mg/kg IM/IV/IO to max 4 mg or 0.5 mg AtroPen and **2-PAM** 25 mg/kg IM or IV slowly to max 2 g/hr	Young children (30 days old–5 yrs old)	**Diazepam** 0.05–0.3 mg/kg IV to a max of 5 mg/dose or **Lorazepam** 0.1 mg/kg slow IV not to exceed 4 mg
				Children (≥ 5 yrs old)	**Diazepam** 0.05–0.3 mg/kg IV to a max of 10 mg/dose or **Lorazepam** 0.1 mg/kg slow IV not to exceed 4 mg
		Older children (4–10 yrs old)	**Atropine** 0.05 mg/kg IV/IM/IO to max 4 mg or 1 mg AtroPen and **2-PAM** 25–50 mg/kg IM or IV slowly to max 2 g/hr	Adolescents and adults	**Diazepam** 5–10 mg up to 30 mg in 8 hr period or **Lorazepam** 0.07 mg/kg slow IV not to exceed 4 mg
		Adolescents (≥ 10 yrs old) and adults	**Atropine** 0.05 mg/kg IV/IM/IO to max 4 mg or 2 mg AtroPen and **2-PAM** 25–50 mg/kg IM or IV slowly to max 2 g/hr		

2-PAM: 2-pralidoxime
IM: intramuscular
IO: intraosseous
IV: intraveneous
PDH: Pediatrics Dosage Handbook
*In general, pralidoxime should be administered as soon as possible, no longer than 36 hours after the termination of exposure. Pralidoxime can be diluted to 300 mg/mL for ease of intramuscular administration. Maintenance infusion of 2-PAM at 10–20 mg/kg/hr (max 2 g/hr) has been described. Repeat atropine as needed every 5–10 minutes until pulmonary resistance improves, secretions resolve, or dyspnea decreases in a conscious patient. Hypoxia must be corrected as soon as possible.
†Meridian Medical Technologies Inc, Bristol, Tenn.
Data sources: (1) Rotenberg JS, Newmark J. Nerve agent attacks on children: diagnosis and management. *Pediatrics*. 2003;112:648–658. (2) Pralidoxime [package insert]. Bristol, Tenn: Meridian Medical Technologies, Inc; 2002. (3) AtropPen (atropine autoinjector) [package insert]. Bristol, Tenn: Meridian Medical Technologies, Inc; 2004. (4) Henretig FM, Cieslak TJ, Eitzen Jr EM. Medical progress: biological and chemical terrorism. *J Pediatr*. 2002;141(3):311–326. (5) Taketomo CK, Hodding JH, Kraus DM. *American Pharmacists Association: Pediatric Dosage Handbook*. 13th ed. Hudson, Ohio; Lexi-Comp Inc: 2006.

TABLE 21-4

MANAGEMENT OF SEVERE NERVE AGENT EXPOSURE

		Management			
		Antidotes*		Benzodiazepines (if neurological signs)	
Nerve Agents	Severe Symptoms	Age	Dose	Age	Dose
• Tabun • Sarin • Cyclosarin • Soman • VX	• Convulsions • Loss of consciousness • Apnea • Flaccid paralysis • Cardio-pulmonary arrest • Strange and confused behavior • Severe difficulty breathing • Involuntary urination and defecation	Neonates and infants up to 6 months old	**Atropine** 0.1 mg/kg IM/IV/IO or 3 doses of 0.25mg AtroPen† (administer in rapid succession) and **2-PAM** 25 mg/kg IM or IV slowly, or 1 Mark I† kit (atropine and 2-PAM) if no other options exist	Neonates	**Diazepam** 0.1–0.3 mg/kg/dose IV to a max dose of 2 mg, or **Lorazepam** 0.05 mg/kg slow IV
		Young children (6 months old–4 yrs old)	**Atropine** 0.1 mg/kg IV/IM/IO or 3 doses of 0.5mg AtroPen (administer in rapid succession) and **2-PAM** 25–50 mg/kg IM or IV slowly, or 1 Mark I kit (atropine and 2-PAM) if no other options exist	Young children (30 days old–5 yrs and adults	**Diazepam** 0.05–0.3 mg/kg IV to a max of 5 mg/dose, or **Lorazepam** 0.1 mg/kg slow IV not to exceed 4 mg
		Older children (4–10 yrs old)	**Atropine** 0.1 mg/kg IV/IM/IO or 3 doses of 1mg AtroPen (administer in rapid succession) and **2-PAM** 25–50 mg/kg IM or IV slowly, 1 Mark I kit (atropine and 2-PAM) up to age 7, 2 Mark I kits for ages > 7–10 yrs	Children (≥ 5 yrs old)	**Diazepam** 0.05-0.3 mg/kg IV to a max of 10 mg/dose, or **Lorazepam** 0.1 mg/kg slow IV not to exceed 4 mg
		Adolescents (≥ 10 yrs old) and adults	**Atropine** 6 mg IM or 3 doses of 2 mg AtroPen (administer in rapid succession) and **2-PAM** 1800 mg IV/IM/IO, or 2 Mark I kits (atropine and 2-PAM) up to age 14, 3 Mark I kits for ages ≥ 14 yrs	Adolescents and adults	**Diazepam** 5–10 mg up to 30 mg in 8-hr period, or **Lorazepam** 0.07 mg/kg slow IV not to exceed 4 mg

IM: intramuscular
IO: intraosseous
IV: intravenous

*In general, pralidoxime should be administered as soon as possible, no longer than 36 hours after the termination of exposure. Pralidoxime can be diluted to 300 mg/mL for ease of intramuscular administration. Maintenance infusion of 2-PAM at 10–20 mg/kg/hr (max 2 g/hr) has been described. Repeat atropine as needed every 5–10 min until pulmonary resistance improves, secretions resolve, or dyspnea decreases in a conscious patient. Hypoxia must be corrected as soon as possible. †Meridian Medical Technologies Inc, Bristol, Tenn.

Data sources: (1) Rotenberg JS, Newmark J. Nerve agent attacks on children: diagnosis and management. *Pediatrics*. 2003;112:648–658. (2) Pralidoxime [package insert]. Bristol, Tenn: Meridian Medical Technologies, Inc; 2002. (3) AtroPen (atropine autoinjector) [package insert]. Bristol, Tenn: Meridian Medical Technologies, Inc; 2004. (4) Henretig FM, Cieslak TJ, Eitzen Jr EM. Medical progress: biological and chemical terrorism. *J Pediatr*. 2002;141(3):311–326. (5) Taketomo CK, Hodding JH, Kraus DM. *American Pharmacists Association: Pediatric Dosage Handbook*. 13th ed. Hudson, Ohio: Lexi-Comp Inc; 2006.

French family at Marbache, Meurthe et Moselle, France, September 1918. Gas masks were compulsory in the village, due to nearby gas attacks. Photo is the frontispiece of the October 1921 reprint of Will Irwin's book "The Next War" (Dutton, N.Y., 19th printing Oct 1921; first published April 1921.)

J. Davidson Pratt, "Gas Defence from the Point of View of the Chemist" (Royal Institute of Chemistry, London, 1937): "... during the Great War, French and Flemish ... living in the forward areas came unscathed through big gas attacks by going into their houses, closing the doors - the windows were always closed in any case - and remaining there..."

London 1941 baby gas mask drill


Hand pumped (asthmatic)
Baby's
Hospital patient's
Police /warden
Civilian
Soldier's until 1942
Small child's (mickey mouse)

Breathe Freely !

THE TRUTH ABOUT POISON GAS

JAMES KENDALL

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1938

CASUALTIES IN INITIAL GAS ATTACKS

Gas	*Date*	*Amount Used In Tons*	*Lethal Concentration* *	*Non-fatal injuries*	*Deaths*
Chlorine	Apr. 22, 1915	168	5·6	15,000	5,000
Phosgene	Dec. 19, 1915	88	0·5	1,069	120
Mustard	July 12, 1917	125	0·15	2,490	87

(* mg/litre for 10 minutes exposure unprotected)

between September 15 and November 11, 1918, 2,000,000 rounds of gas shell, containing 4,000 tons of mustard gas, were fired against the advancing British troops; our losses therefrom were 540 killed and 24,363 injured. Gas defence had progressed to the point where it took nearly 8 tons of mustard gas to kill a single man !

The first salvo of gas shells often reaches the trenches before the occupants don their masks, whereas the Londoner will receive ample warning of the approaching danger.

The alarmist and the ultra-pacifist love to quote the fact that one ton of mustard gas is sufficient to kill 45,000,000 people. This would indeed be true if the 45,000,000 people all stood in a line with their tongues out waiting for the drops to be dabbed on, but they are hardly likely to be so obliging. One steam-roller would suffice to flatten out all the inhabitants of London if they lay down in rows in front of it, but nobody panics at the sight of a steam-roller.

Ever since the Armistice, three classes of writers have been deluging the long-suffering British public with lurid descriptions of their approaching extermination

These three classes are pure sensationalists, ultra-pacifists and military experts.

perpetrators of such articles may not recognize themselves that what they are writing is almost entirely imaginary, but they do want to get their manuscript accepted for the feature page of the *Daily Drivel* or the *Weekly Wail.* In order to do that, they must pile on the horrors thick, and they certainly do their best

The amount of damage done by such alarmists cannot be calculated, but it is undoubtedly very great.

poison gas has a much greater news value. It is still a new and mysterious form of warfare, it is something which people do not understand, and what they do not understand they can readily be made to fear.

The recent film *Things to Come,* in particular, has provided a picture of chemical warfare of the future which shows how simply and rapidly whole populations will be wiped out. Millions of people, perhaps, have been impressed by the authority and reputation of Mr. H. G. Wells into believing that this picture represents the plain truth.

Exhibit 'B' is the work of the ultra-pacifist. He abominates war and everything connected with war to such an extent that he paints a highly coloured picture of its horrors, in the most extreme Surrealistic style, with the object of frightening the public to the point where they will relinquish, in the hope of escaping war, even the right of self-defence. His motives may be praiseworthy, but his methods are to be deplored.

Tel. No.: VICtoria 6826

Any communication on the subject of this letter should be addressed to—

The Under Secretary of State,
Home Office (A.R.P. Dept.),
Horseferry House,
Thorney Street,
London, S.W.1.

and the following number quoted:—
701,602/109

HOME OFFICE,
Air Raid Precautions Dept.,
HORSEFERRY HOUSE,
THORNEY STREET,
LONDON, S.W.1.

31*st December*, 1937.

Sir,

Experiments in Anti-Gas Protection of Houses

I am directed by the Secretary of State to transmit, for the information of your Council, the annexed Report describing in detail the experiments to which reference was made by the Parliamentary Under Secretary of State in his speech on the second reading of the Air Raid Precautions Bill in the House of Commons on the 16th November.

The experiments were conducted by the Chemical Defence Research Department under the aegis of a special Sub-Committee of the Chemical Defence Committee. That Sub-Committee was composed of eminent experts not in Government employment, and included a number of distinguished University professors and scientists.

I am,
Sir,
Your obedient Servant,
R. R. Scott.

The Clerk of the County Council.
The Town Clerk.
The Clerk to the District Council.

Issued to all
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County Borough Councils (and the Corporation of the City of London)
Metropolitan Borough Councils
Municipal Borough Councils
Urban and Rural District Councils
in England and Wales
Copies sent for information to Chief Officers of Police in England and Wales.

PROTECTION AGAINST GAS

REPORT OF EXPERIMENTS CARRIED OUT BY THE CHEMICAL DEFENCE RESEARCH DEPARTMENT

Handbook No. 1 issued by the Air Raid Precautions Department of the Home Office describes the steps which the public are advised to take in order to protect themselves against the effects of any chemical warfare gases which might be employed by enemy aircraft in time of war.

The gist of these recommendations is:—

First, to go indoors.

Secondly, to arrange for the room into which you go to be made as gas-proof as possible.

Thirdly, to take with you the respirator which will have been issued to you.

Whilst it has never been claimed that any one of these steps by itself will make an individual completely safe, experiments and trials have shown that each of these measures is by itself of considerable value and that when all of them are adopted a very high degree of protection is obtained. An outline is given below of certain typical experiments which have been carried out.

These particular experiments were carried out with four different types of actual war gas. The first four experiments to be described will show the degree of protection that is obtained from each type of gas merely by going indoors and shutting the doors and windows.

As explained in Handbook No. 1*, a chemical warfare gas may be dropped from aircraft either as spray or in bombs. In the former case the liquid drops fall like rain, and it is obvious that by going indoors the public will avoid them. On the other hand, if gas bombs are dropped, people who have gone indoors will avoid being splashed by the chemical in the bomb, and even in an ordinary room they will receive some protection from the gas cloud. The amount of protection obtained in a house which has not been treated in any way can be gathered from the following experiments.

(a) *Protection obtained in a house which has not been treated in any way.*

The house employed was a gamekeeper's cottage with three rooms on the ground floor and three rooms upstairs. It had been unoccupied for about 15 years but was in a reasonable state of repair. It was to a large extent sheltered by belts of

---

* A.R.P. Handbook No. 1, "Personal Protection against Gas", price 6d. (8d. post free): published by H.M. Stationery Office (see back page).

trees which reduced the strength of the wind in the vicinity of the cottage to about one-eighth of that in the open. In this respect therefore the location of the cottage resembled a house in a town. In one experiment over a ton of actual chlorine gas was released 20 yards from the house so that the wind carried it straight on to the unprotected room. A very strong gas cloud was thus maintained outside the house for about 40 minutes, during which time the gas gradually penetrated to the inside. A fire was burning in the hearth the whole time, and the only measures taken to exclude the gas consisted of closing the doors and windows in the normal way.

Human beings who occupied this unprotected room found that gas penetrated slowly into the room, and after about seven minutes is became necessary for them to put on their respirators. Had these men been outside the house, they would have been compelled to put on their respirators immediately, since otherwise the very intense gas cloud would have caused instantaneous incapacitation and ultimate death.

If the gas, which with its containers weighed about 2½ tons, had been released more quickly, the strength of the gas cloud would have been greater but the time during which the house was enveloped by it would have been correspondingly shorter.

It is important to appreciate properly the severity of this trial. The quantity of gas concentrated on this house could under practical conditions only be obtained by several large bombs dropping very close to the building. The period of exposure to the maximum effects of the gas was also many times longer than would normally be experienced under most practical conditions, since the initial cloud from a gas bomb soon begins to be diluted and dispersed by the action of even quite moderate winds. It is clear that conditions similar to those of the experiment are extremely severe, and are such as would be likely to occur very rarely indeed and to a very small number of houses.

It should also be noted that the cottage used in this experiment had no carpets or other floor coverings. Most of the gas which leaked in came through the spaces between the floor boards, and it is therefore clear that much less would have got into an ordinary room in which there was a carpet, linoleum, or a solid floor.

In another experiment the house was surrounded at a distance of 20 yards by large shallow trays which were filled with mustard gas, the trays being spaced a few yards apart. By this means the vapour given off by the mustard gas was carried on to the house no matter how the direction of the wind varied. As the weather at the time was not very warm, the conditions of the experiment were made more severe by producing a fine spray of mustard gas at a point 10 yards to windward of

the house so that the house was enveloped in the resultant cloud of mustard gas for a period of an hour. The cloud produced in this way was about a hundred times as strong as that caused by the evaporation of the mustard gas from the trays. Animals were placed in an unprotected room in the house and remained there during the spraying period and for a further 20 hours while the house was subjected to the vapour of mustard gas given off from the trays. Observations made upon the animals during the three subsequent days and also post mortem examination showed that none of them was seriously harmed by the mustard gas.

The third type of gas used was tear gas. In this experiment the same cottage was enveloped for an hour in an intense atmosphere of tear gas produced by spraying the gas into the air at a point 10 yards upwind of the house. Men who were stationed 200 yards downwind from the house and in the track of the gas cloud were incapacitated in about a minute, and in some cases in 20 seconds. On the other hand, men who occupied rooms in the house which had received no treatment beyond the closing of the windows and doors found no need to put on their respirators for the first 13 minutes. The tear gas gradually penetrated into these unprotected rooms, although after three-quarters of an hour the strength of the gas inside the house was still very much less than that outside.

In the fourth experiment the cottage was enveloped for 20 minutes in a dense cloud of arsenical smoke. Men occupying an unprotected room of the house found that the arsenical smoke penetrated into the room, but the strength of the cloud inside was much less than that outside. When Civilian respirators were worn in this room, complete protection was obtained. Men who were stationed 200 yards downwind of the house and in the path of the gas cloud were rapidly affected, but when they wore Civilian respirators no effects were felt.

The above four examples clearly demonstrate that, apart from the protection which a house provides against falling airplane spray, some measure of protection is afforded even by an ordinary unprotected room against gas clouds such as are produced by bombs close to the building.

(b) *Protection afforded by a house treated in accordance with Air Raid Precautions Handbook No.* 1.

A brief account will now be given of four further experiments with the same four war gases in order to illustrate the added protection which can be obtained by treating a room in accordance with the instructions given in Air Raid Precautions Handbook No. 1. These experiments were also conducted with the cottage already mentioned. The room selected for treatment was situated on the ground floor on the windward side

of the house so that it was subjected to the full effect of the gas and the wind. It measured about 12 feet square. The Air Raid Precautions instructions for excluding gas were carried out by unskilled men, the official procedure being rigidly followed. As the house was not provided with carpets or other floor covering, it became necessary to seal up the joints between the boards over the whole of the floor of the selected room. This was done by pasting strips of paper along the joints between the floor boards. Some of these strips became displaced by the boots of the men who were inside the room, and an appreciable leakage of gas into the room undoubtedly occurred due to this cause. Two tons of chlorine were released 20 yards from the house, the time of emission being an hour. Animals were placed in the house, some in the " gas protected " room and others in rooms which had received no such treatment. The latter set of animals were killed by the gas which penetrated into the unprotected rooms under these very severe conditions. The animals in the " gas protected " room, however, were unaffected and remained normal, notwithstanding the severity of the trial.

An experiment with mustard gas, similar to that already described, was also carried out after the ground floor room on the windward side of the house had been treated in accordance with the Air Raid Precautions Department's procedure. Animals were placed in the room, which was then subjected to the same exposure of mustard gas spray and vapour as before. At the end of 20 hours the animals were removed and a most thorough examination of them showed no evidence of the effects of the gas at all. Animals placed outside the house during the first hour of the experiment were, of course, very seriously affected. The amount of mustard gas penetrating into the room was also measured by chemical methods and it was found that the amount of gas inside the room was so small that a man could have remained there for the whole 20 hours without its being necessary for him to wear a respirator and without any subsequent ill-effects.

The experiment with tear gas previously described was also performed against the " gas protected " room. A number of men occupied this room and found they were able to remain there without its being necessary for them to put on their respirators at any time during the hours that this very severe experiment lasted.

An experiment with arsenical smoke, similar to that already described, was also carried out against the " gas protected " room. The occupants found that the arsenical smoke penetrated the room to an extent which caused some irritation of the nose and throat and eventually rendered the wearing of respirators desirable to ensure comfort. After putting on the respirator, no

discomfort was felt throughout the remainder of the experiment. Men who left the " gas protected " room wearing their Civilian respirators were able to traverse the densest part of the cloud without discomfort. Under these severe conditions the presence of the arsenical smoke could be detected, but the effects were insignificant.

It is important to appreciate fully the severity of the conditions imposed in the two trials with arsenical smoke. A very high concentration of the irritant smoke was maintained around the house for 20 minutes. Under practical conditions such a high concentration could be produced only by a large and efficiently designed bomb falling close to the building, and then only for a short period. The conditions of the trials were therefore extremely severe and represent a situation which would only rarely be met, and in which only a small number of houses would be involved.

From this second series of experiments it will be seen that treating a room in accordance with the recommendations of the Air Raid Precautions Department does reduce very considerably the amount of gas penetrating into the room, and that a room so treated is correspondingly safer than a room which has received no such treatment.

Indeed, in the case of the experiments with mustard gas and tear gas, the amount of gas which was able to penetrate into the gas protected room was so small that no further measures of protection were necessary.

In the experiment with chlorine, although the amount of gas which entered the treated room was insufficient to injure the animals, human beings who occupied the room during this extremely severe test could smell the gas. They were provided with Civilian respirators, and they found that by putting these respirators on they were completely protected against every trace of gas. Some of these individuals then left the " gas protected " room, passed out of the house, and traversed the lethal cloud of gas which enveloped it. Although they deliberately stood in the densest part of the cloud for some minutes, no trace of the gas passed through their respirators.

Similarly the experiments with arsenical smoke show that although, under the most severe conditions, the cloud may penetrate into the " gas protected " room in sufficient quantity to be detected, or even to cause some irritation, the effects are materially reduced in a room so treated. It is also demonstrated that wearing a Civilian respirator affords complete protection against any smoke which may gain access to the room. The respirator also enabled individuals to pass through an extremely dense cloud of arsenical smoke in complete safety.

The experiments which have been outlined in this statement were purposely designed to represent the most severe conditions likely to be met. The results all combine to show that if the instructions given in Air Raid Precautions Handbook No. 1 are carried out a very high standard of protection is obtained. With regard to the first precaution it has been shown that going indoors and closing the doors and windows affords some measure of protection, even though the room occupied has not been specially prepared. In these circumstances there is ample time to put on the respirator at leisure if this should be necessary. If the second precaution of rendering the room as gas-proof as possible has been carried out, then the occupants will normally be able to remain in complete safety and comfort without further protection. Under the most severe conditions sufficient gas may penetrate such protected rooms to be recognized or even to cause slight irritation. When this occurs the respirator can be put on though in many cases this will be as a matter of convenience and extra precaution rather than real necessity. With regard to the Civilian respirator it has been shown that this will, in conjunction with the above precautions, provide complete safety for any period for which it is likely to be required. It has further been demonstrated that this respirator will enable the wearer to reach a place of safety even if he should for a time be exposed to the most dangerous situation—for example if he is caught out of doors in a gas cloud, or if his gas-protected room becomes damaged and he is compelled to seek shelter elsewhere.

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Manual of Basic Training

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BASIC CHEMICAL WARFARE

PAMPHLET No. 1

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1949

CHAPTER VII

51. COLLECTIVE PROTECTION

Every individual can rely on his respirator for his own protection against war gas, and this is his primary defence, but the protection which is afforded against vapour, by buildings in sound condition, is of considerable value and against liquid and spray is complete.

HOME OFFICE

SCIENTIFIC INTELLIGENCE OFFICERS' OPERATIONAL NOTES

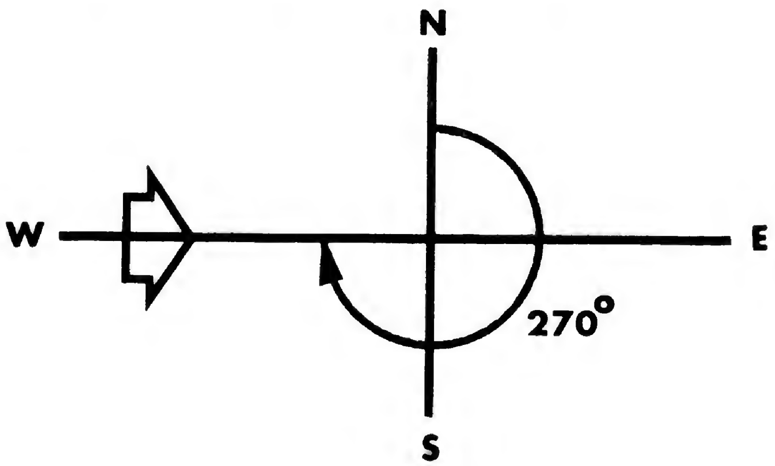
RESTRICTED

The information given in this document is not to be communicated, either directly or indirectly, to the Press or to any person not authorised to receive it.

Mechanism of fallout

Definitions

Wind direction is the direction from which the wind blows, and is given in degrees measured clockwise from north. E.g. A 270° wind blows from the west.



Wind speed is actually measured in knots, but the unit of speed usually used by the SIO is the mile per hour (mph).

1 knot = 1 nautical mile per hour
1 nautical mile = 6080 feet
1 knot = 1.15 mph

N.B. In meteorological forecasts received by the SIO wind speeds will normally be in mph. If a forecast is mistakenly transmitted in knots, then the SIO should transform, using the above relationship. In approximate calculations the difference between a knot and a mile per hour may be neglected.

Winds changing direction with time

(a) If a wind turns clockwise it is said to be veering.
(b) If a wind turns anticlockwise it is said to be backing.

A forecast concerns meteorological data only.

A prediction indicates where fallout may go. It is based on a forecast and on bomb data.

A micron (μ) is one millionth of a metre.
1000 microns = 1 millimetre.

Useful wind data

The following data applies to the 0-60,000, 0-70,000 and 0-80,000 feet mean vector winds.

(a) Variation with speed

Probabilities of occurrence of speeds (all directions)

Speed range (mph)	0-7	7-18	18-35	35+
Percentage probability	4	17	36	43

(b) Variation with direction

Probabilities of directions occurring in 60° sectors (all speeds)

Wind direction (degrees)	0-60	60-120	120-180	180-240	240-300	300-360
Percentage probability	7	4	5	17	41	26

(c) Angular wind shear

This is defined for the present purpose as the angle which includes the directions of all the mean vector winds up to the 0-90,000 feet one, excluding the surface wind. This angle will give a very crude idea of the amount of lateral spreading which might occur in the fallout pattern.

Percentage probability of occurrence of angular shear

Angular shear (degrees)	Mean vector wind speed (mph)				Total
	0 - 7	7 - 18	18 - 35	35 +	
0-15	0	$2\frac{1}{2}$	$9\frac{1}{2}$	21	33
15-30	$\frac{1}{2}$	$3\frac{1}{2}$	13	11	28
30-75	$\frac{1}{2}$	7	$10\frac{1}{2}$	10	28
75 +	3	4	3	1	11
Total	4	17	36	43	100

Mode of decay

Any single radioisotope decays according to an exponential law $N_t = N_o e^{-\lambda t}$, where N_o and N_t are the number of atoms present initially and at time t. λ is a decay constant and can be shown to equal 0.693/T, where T is the half-life of the isotope, i.e. if the activity was originally, say, 8 units, then it will have decayed to 4 units after time T, 2 units after time 2T, 1 unit after time 3T, etc.

Fission products from a nuclear explosion are a mixture of over 200 different radioisotopes with half-lives varying from fractions of a second to many thousands of years. Many of them, moreover, are not produced immediately but are the result of the decay of other nuclides. In addition, the mixture may contain some activity due to neutron activation of the bomb components resulting in the formation of neptunium 239. The decay of this mixture is not exponential and thus cannot be described by a half-life. From nuclear weapons trials it has been found for the first 100 days to follow approximately the $t^{-1.2}$ power law, i.e. $R_t = R_1 t^{-1.2}$, where R_1 and R_t are the dose-rates at 1 hour and t hours after detonation

Factors upsetting normal decay

Probable causes of deviation from the $t^{-1.2}$ decay law are:-

(a) fractionation
(b) neutron activation of soil elements
(c) weathering
(d) rigging or salting of weapons

Fractionation

This is a complex condensation process and is by no means fully understood. Its effect is to give the close-in FO a different composition and hence a different decay from the more distant FO downwind. For example, close-in FO has been found to contain less strontium 90.

Two likely causes of fractionation are:-

(a) as the fireball cools the nuclides with the higher boiling points condense first and do so while the larger particles forming the close-in FO are still present in the cloud. The more volatile nuclides condense later when the larger particles have left the cloud and so tend to contaminate the lighter particles which are carried further downwind.

(b) certain of the fission products are inherently gaseous (e.g. krypton) or have gaseous precursors (e.g. caesium 137). The heavier particles fall out before these nuclides have decayed to non-gaseous daughters capable of condensing on to them. Close-in FO is therefore deficient in these elements. Conversely the smaller particles forming the more distant FO are enriched in them.

Neutron activation of soil elements

For FO to be produced on a substantial scale, the explosion must take place on or near the ground, in which case the radioactivity from the fission products and the bomb materials is supplemented by neutron-induced activity from certain elements in the soil. For the 50% fission weapon this extra activity is small but may be appreciable for the so-called "clean" bomb where possibly only 10% of the total energy is from fission. The number of spare neutrons is doubled and the fission product activity reduced by a factor of 5. Under these circumstances induced activity can become a substantial proportion of the whole. Calculations made on typical UK soils show that the elements most likely to contribute to this activity are sodium and manganese. Under neutron activation these form the gamma emitters sodium 24 and manganese 56. Sodium and manganese are present in soils in varying amounts according to the locality. Sodium, for example, is more abundant in the rock-salt areas of Cheshire and in regions of igneous rock formation. Manganese is fairly uniformly distributed but usually only in small amounts.

If a large quantity of a particular isotope such as sodium 24 is added to a fission product mixture obeying the $t^{-1.2}$ law, the effect is to increase the dose-rate by an amount varying with time. It can be shown that the isotope exerts its maximum proportional effect at a time equal to 1.73 times its half-life. For sodium 24 and manganese 56 the details are:-

Isotope	Half-life (hours)	Time of maximum proportional effect (hours)
Na24	15	26
Mn56	$2\frac{1}{2}$	$4\frac{1}{2}$

For a 10% fission bomb the sodium 24 contribution to the total DR at H + 26 hours could be over 80% for some bomb designs and soil constitutions; the manganese 56 contribution at H + $4\frac{1}{2}$ hours could be over 10%.

Notes on BW and CW

General

Toxicological warfare can consist either of a tactical attack with chemical weapons producing an immediate incapacitating effect, or of a strategic attack with biological weapons which have a delayed effect.

The new Civilian Respirator (C7), with pneumatic tube face fitting which is comfortable for long periods of wearing, affords excellent protection against BW and CW attacks.

BW

In attacks on populations, since the airborne hazard is the main one, only agents of high infectivity and high virulence (i.e. a small number of organisms required to produce infection and cause severe illness), combined with viability for many hours in the atmosphere, are likely to prove effective.

Some representative pathogenic micro-organisms

Bacterial	Anthrax	(lethal, very persistent spores but relatively low infectivity)
	Brucellosis	(incapacitating)
	Tularaemia	(incapacitating or lethal)
	* Rickettsial	Q fever (like typhus)
	* Viruses	Encephalomyelitis (brain fever)
		Smallpox (epidemic)

Personal protection

Respirators and discardible covers for head and body may be used. Extreme personal cleanliness is necessary. Total dosage can be reduced very considerably in a closed room in a house by sealing window cracks and door gaps before the arrival of contamination and ventilating the room fully as soon as it has passed.

Decontamination

Where appropriate the following measures may be taken:-

(a) weathering for a few days will destroy most bacterial agents other than anthrax spores
(b) use of bleach solution
(c) scattering petrol and firing it on open contaminated ground.

CW

Mustard gas and anticholinesterase agents (persistent and non-persistent nerve gases) are the CW agents most likely to be encountered in a tactical battle.

Building/ Vehicle Type	Air Exchange Rate (ACH)	Time Building Is Exposed (hr.)	Time of Occupancy from Cloud Arrival (hr.)	Shielding Factor
Residential Building (Windows Closed)[1]	0.53	0.25	0.25	15.8
	0.08-3.24	0.25	0.25	100.7-3.2
Residential Building (Windows Open)[1]	6.4	0.25	0.25	2.0
Nonresidential Building[1]	1.285	0.25	0.25	6.9
	0.3-4.1	0.25	0.25	27.3-2.7
Vehicle[1]	36	0.25	0.25	1.1
Mass-Transit Vehicle[1]	1.8-5.6	0.25	0.25	5.1-2.2
Stationary Automobile[2]:				
Windows Closed/No Ventilation	1.0-3.0	0.25	0.25	8.7-3.4
Windows Closed/Fan On Recirculation	1.8-3.7	0.25	0.25	5.1-2.9
Windows Open/No Ventilation	13.3-26.1	0.25	0.25	1.4-1.2
Windows Open/Fan On Fresh Air	36.2-47.5	0.25	0.25	1.1

1 Ted Johnson, A Guide to Selected Algorithms, Distributions, and Databases used in Exposure Models Developed by the Office of Air Quality Planning and Standards (Chapel Hill, NC: TRJ Environmental, Inc., 22 May 2002), http://www.epa.gov/ttn/fera/data/human/report052202.pdf. Accessed 8 January 2008.

2 J. H. Park et al., "Measurement of Air Exchange Rate of Stationary Vehicles and Estimation of In-Vehicle Exposure," Journal of Exposure Analysis & Environmental Epidemiology 8, no. 1 (January–March 1998):65-78.

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OAK RIDGE NATIONAL LABORATORY

MARTIN MARIETTA

ORNL/TM-10423

Technical Options for Protecting Civilians from Toxic Vapors and Gases

C. V. Chester

Date Published - May 1988

Prepared for
Office of Program Manager
for
CHEMICAL MUNITIONS
Aberdeen Proving Grounds, Maryland

OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

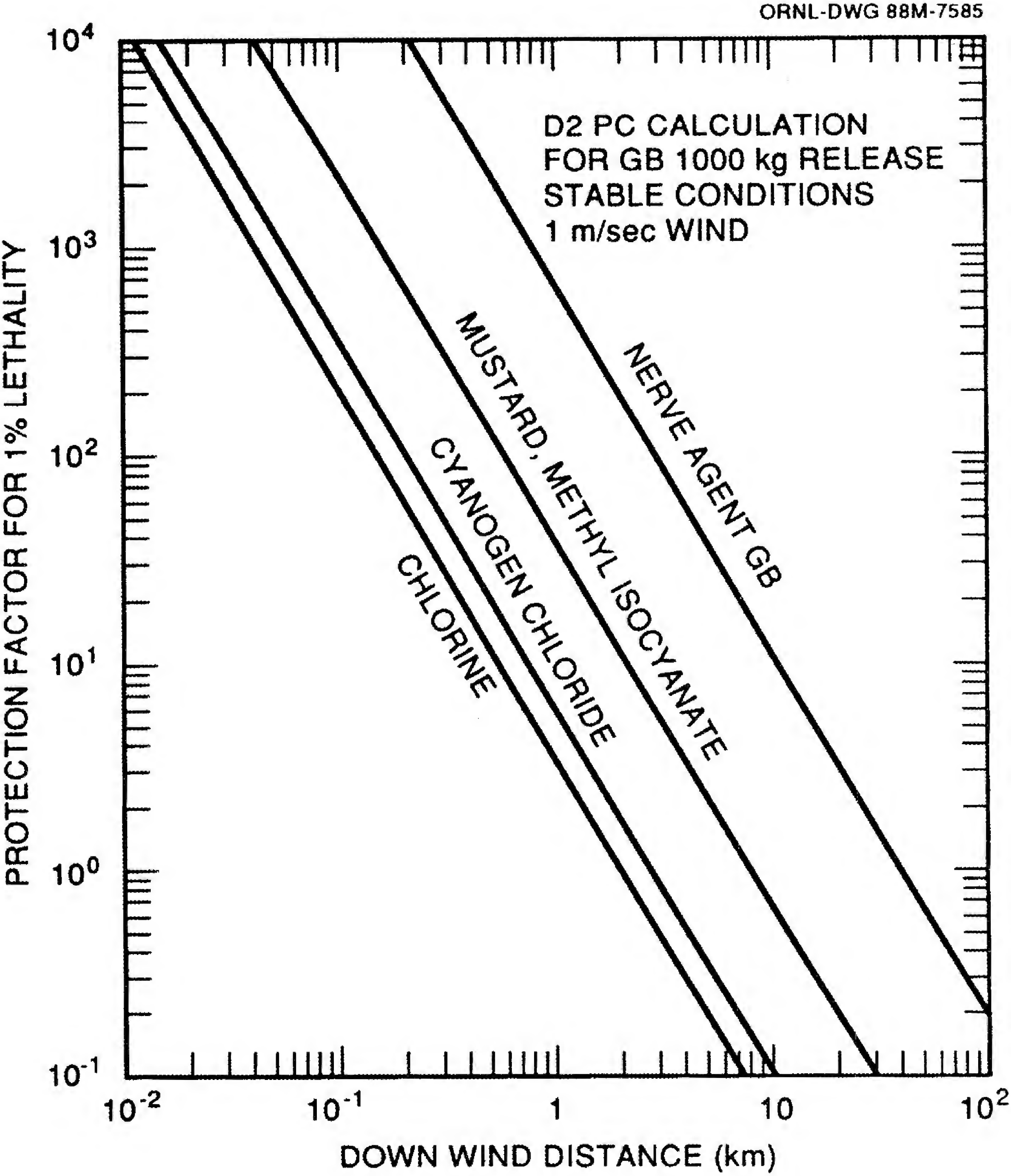

Fig. 1 Dose vs Downwind Distance for Some Very Toxic Gases

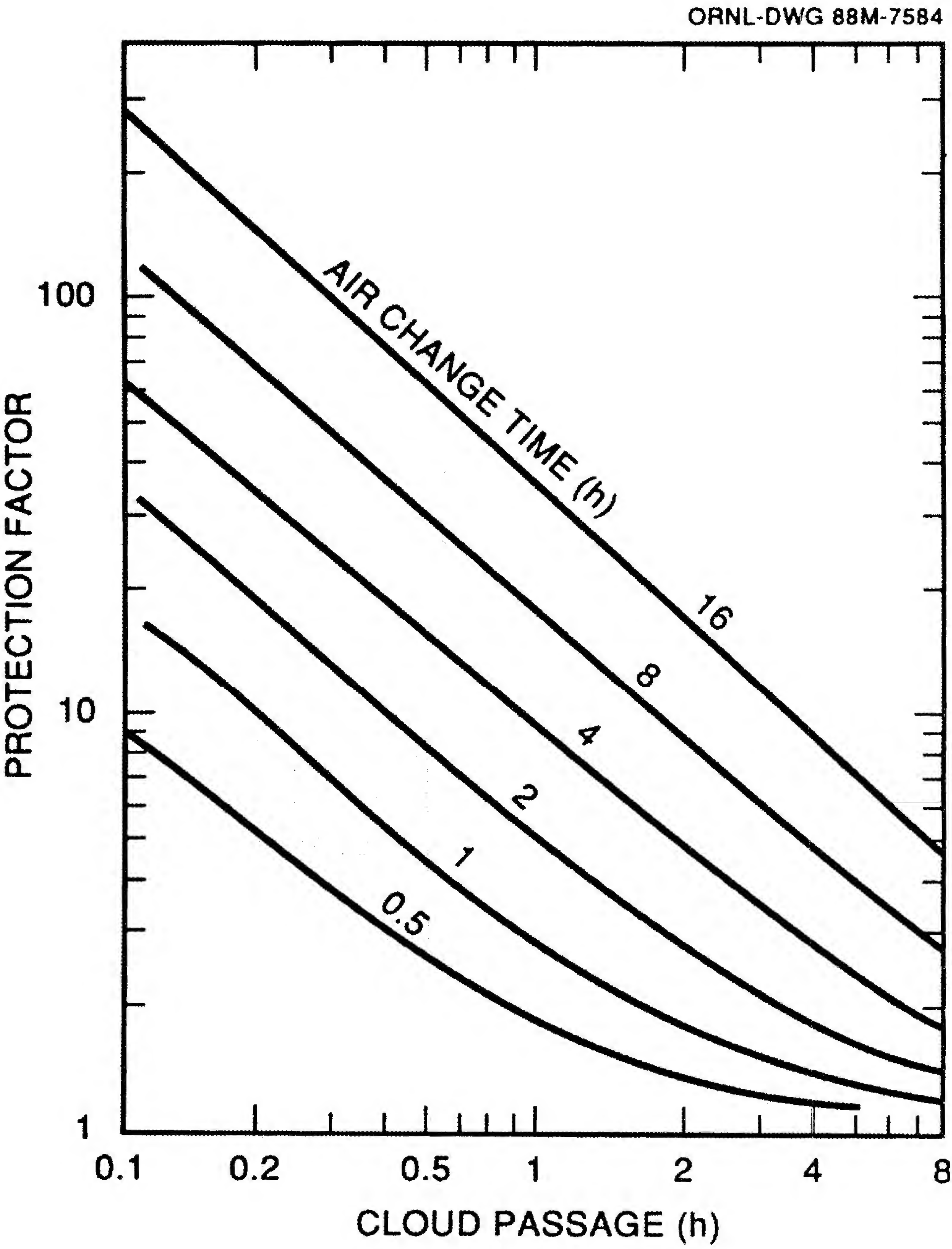

Fig. 2 Protection Factor of Leaky Enclosures

ORNL-DWG 88M-7581

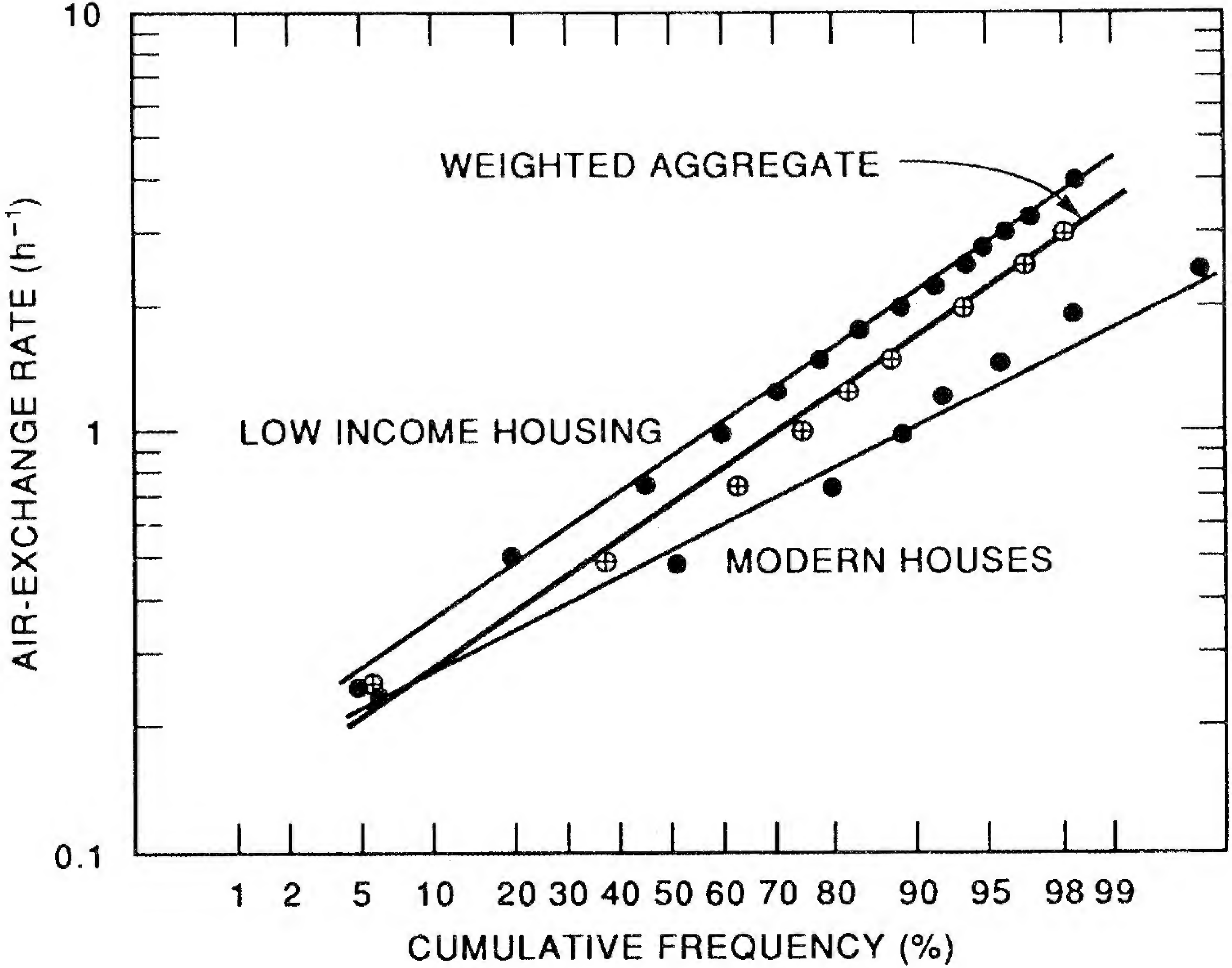

Fig. 3 Infiltration Rates of American Residences

ORNL/TM-2001/154

Energy Division

Will Duct Tape and Plastic Really Work? Issues Related To Expedient Shelter-In-Place

John H. Sorensen
Barbara M. Vogt

Date Published—August 2001

Prepared for the
Federal Emergency Management Agency
Chemical Stockpile Emergency Preparedness Program

Prepared by
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Although vapors, aerosols, and liquids cannot permeate glass windows or door panes, the amount of possible air filtration through the seals of the panes into frames could be significant, especially if frames are wood or other substance subject to expansion and contraction. To adequately seal the frames with tape could be difficult or impractical. For this reason, it has been suggested that pieces of heavy plastic sheeting larger than the window be used to cover the entire window, including the inside framing, and sealed in place with duct or other appropriate adhesive tape applied to the surrounding wall.

Another possible strategy would be to use shrink-wrap plastic often used in weatherization efforts in older houses. Shrink-wrap commonly comes in a 6 mil (0.006-in.) thickness and is adhered around the frame with double-faced tape and then heated with a hair dryer to achieve a tight fit. This would likely be more expensive than plastic sheeting and would require greater time and effort to install. Because double-faced tape has not been challenged with chemical warfare agents, another option is to use duct tape to adhere shrink-wrap to the walls. Currently, we do not recommend using shrink-wrap plastics because of the lack of information on its suitability and performance.

3. WHY WERE THESE MATERIALS CHOSEN?

Duct tape and plastic sheeting (polyethylene) were chosen because of their ability to effectively reduce infiltration and for their resistance to permeation from chemical warfare agents.

3.1 DUCT TAPE PERMEABILITY

Work on the effectiveness of expedient protection against chemical warfare agent simulants was conducted as part of a study on chemical protective clothing materials (Pal et al. 1993). Materials included a variety of chemical resistant fabrics and duct tape of 10 mil (0.01-in.) thickness. The materials were subject to liquid challenges by the simulants DIMP (a GB simulant), DMMP (a VX simulant), MAL (an organoposphorous pesticide), and DBS (a mustard simulant). The authors note that simulants should behave similarly to live agents in permeating the materials; they also note that this should be confirmed with the unitary agents. The study concluded that "duct tape exhibits reasonable resistance to permeation by the 4 simulants, although its resistance to DIMP (210 min) and DMMP (210 min) is not as good as its resistance to MAL (>24 h) and DBS (> 7 h). Due to its wide availability, duct tape appears to be a useful expedient material to provide at least a temporary seal against permeation by the agents" (Pal et al. 1993, p. 140).

3.2 PLASTIC SHEETING PERMEABILITY

Tests of the permeability of plastic sheeting (polyethylene) challenged with live chemical warfare agents were conducted at the Chemical Defense Establishment in Porton Down, England in 1970 (NATO 1983, p. 133). Agents tested included H and VX, but not GB. Four types of polyethylene of varying thickness were tested: 2.5, 4, 10 and 20 mil (0.0025, 0.004 in., 0.01 in., and 0.02 in.). The results of these tests are shown in Table 1.

Table 1: Permeability of plastic sheeting to liquid agent

	Breakthrough time (h)	
Thickness	VX	H
0.0025	3	0.3
0.004	7	0.4
0.01	30	2
0.02	48	7

Source: NATO 1983, p. 136.

The data shows that at thickness of 10 mil or greater, the plastic sheeting provided a good barrier for withstanding liquid agent challenges, offering better protection against VX than for H. Because the greatest challenge is from a liquid agent, the time to permeate the sheeting will be longer for aerosols and still longer for vapors, but the exact relationship is unknown due to a lack of test data.

NATO Civil Defense Committee 1983. *NATO Handbook on Standards and Rules for the Protection of the Civil Population Against Chemical Toxic Agents*, AC/23-D/680, 2nd rev.

Pal, T., G.Griffin, G. Miller, A. Watson, M. Doherty, and T. Vo-Dinh. 1993. “Permeation Measurements of Chemical Agent Simulants Through Protective Clothing Materials,” *J. Haz. Mat.* **33**:123-141.

THE PROTECTION OF THE PUBLIC FROM AERIAL ATTACK

Being

A CRITICAL EXAMINATION OF THE RECOMMENDATIONS PUT FORWARD BY THE AIR RAID PRECAUTIONS DEPARTMENT OF THE HOME OFFICE

by

THE CAMBRIDGE SCIENTISTS' ANTI-WAR GROUP

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the time taken for the gas to leak out to half its original value was measured in four rooms—the basement of a shop, the dining-room of a semi-detached house, the sitting-room of a Council house and the bathroom of a modern villa. As stated above the leakage half-times for these rooms were $2\frac{1}{2}$, $2\frac{1}{2}$, $3\frac{1}{2}$ and $9\frac{1}{4}$ hours respectively. The reason for the last room being so much better than all the others is that it has steel-frame windows which were sealed with plasticine, painted and tiled walls, and a concrete floor covered with cork tiles.

Note: even a 1 mile wide gas cloud 41
passes in 6 min in 10 miles/hr wind
(hence good protection) This property of drifting with the wind is of some importance, for it means that the gas will not remain for long periods in any one place except on still days.

Now it may be objected that, although the "gas-proof" room is not hermetically sealed, it will nevertheless protect the occupants for the two or three hours necessary in case of an attack by a choking gas.

We assume that the gas blows away so quickly that every 10 minutes its concentration is halved. In Engelhard's experiments it took 10 minutes to liberate the gas from its cylinders, so that this assumption is reasonable. Then a person occupying a good "gas-proof" room, the leakage half-time of which (defined on p. 18) is 3 hours, would have breathed a lethal dose of phosgene in 2 hours.

Gas-schutz und Luftschutz, *4*, 174, 1934

Complete lies: bombs are dropped, not cylinders. Engelhard's 1934 article in the Nazi controlled "Gas protection and air protection" journal is enemy propaganda; the Nazis kept the facts secret

As, however, our experiments on the "gas-proof" room illustrate quite clearly that the ordinary dwelling-house is quite incapable of affording protection, it probably will not matter much what a civil population does under a gas and incendiary attack. Nor is it profitable to argue whether the gas or incendiary bomb is the more devastating, as it is necessary to contemplate an air attack in which both will be employed, with a sprinkling of high explosive bombs, which will considerably heighten the "psychological effect." This is the type of attack which people in large towns must expect if war breaks out; our task in this section is to discuss the proposals of the Home Office for dealing with incendiary bombs, remembering that whoever deals with them will require, almost certainly, simultaneous protection against gas. PROVED WRONG!

 PROPAGANDA

extreme lightness and cheapness of the incendiary bomb must be borne in mind. Mr. Noel-Baker cites the case of a single aeroplane carrying a load of less than a ton of bombs which succeeded in starting three hundred fires, and if we take a specimen raid of nine bombers, each carrying a thousand "kilo" bombs, nine thousand of these could be dropped on an area of two square miles. If very generous allowances are made for failures to function and for bombs falling on non-inflammable sites, in an urban area one fifth at least of these bombs should cause fires. This makes one thousand eight hundred fires. The danger of fire spreading over several blocks of buildings as in the San Francisco (1906) and Tokyo (1933) earthquakes, making the centre of the conflagration quite unapproachable by fire brigades is obvious.

To summarise this section, we reach the conclusion:

(*a*) That for individuals the cost of making buildings impenetrable to incendiary bombs is prohibitive.

(*b*) That, bearing in mind the probability of combined incendiary and gas attack, the civilian population will have considerable difficulty in extinguishing fires caused by incendiary bombs in private houses, unless assisted by experts. ← WRONG!

(*c*) That the fires caused by a raid such as is outlined above would very likely be impossible to deal with, even with the improved fire brigade organisation envisaged by the Home Office, because of the probable amalgamation of separate outbreaks into a vast conflagration.

FM 3-10

DEPARTMENT OF THE ARMY FIELD MANUAL

CHEMICAL AND BIOLOGICAL WEAPONS EMPLOYMENT

HEADQUARTERS, DEPARTMENT OF THE ARMY
FEBRUARY 1962

	1	2	3	4	5 Employment data			
					(a) Range (Meters)		(b)	(c)
Line	Munition	Agent	Delivery system	User	(1) Maximum	(2) Minimum	Error	Fuze (Capability)
1	Shell, M2A1	HD	4.2-inch Mortar	US ARMY USMC	3, 930	180	←Obtain from delivery unit or appropriate firing tables→	M8PD
2	Shell, M360	GB	105-mm Howitzer, M2A1, M2A2, M4, M4A2, M52.	US ARMY USMC	11, 140	862		M508PD
3	Shell, M60	HD	105-mm Howitzer, M2A1, M2A2, M4, M4A2, M52.	US ARMY USMC	11, 140			M51A5PD
4	Shell, M121	GB	155-mm Howitzer, M1, M1A1, M44.	US ARMY USMC	14, 950			M508PD
5	Shell, M110	HD	155-mm Howitzer, M1, M1A1, M44.	US ARMY USMC	14, 950			M51A5PD
6	Shell, T__(M121)	VX	155-mm Howitzer, M1, M1A1, M44.	US ARMY USMC	14, 950			T76E6VT [1]
7	Shell, M122	GB	155-mm Gun, M2, M53	USMC	23, 500			M508PD
8	Shell, M104	HD	155-mm Gun, M2, M53	USMC				M51A5PD
9	Shell, Gas, 175-mm	GB	M107 Gun (SP)	US ARMY	31, 500	180		
10	Shell, Gas, 175-mm	VX	M107 Gun (SP)	US ARMY	31, 500	180		VT-M514A1
11	Shell, T174	GB	8-inch Howitzer, M2, M2A1, M55.	US ARMY USMC	16, 930			M51A5PD
12	Shell, T174	VX	8-inch Howitzer, M2, M2A1, M55.	US ARMY USMC.	16,930			T2061VT
13	Rocket, M55, 115-mm (BOLT)	GB	Launcher, M91	US ARMY USMC.	10,970	2,740		M417PD
14	Rocket, M55, 115-mm (BOLT)	VX	Launcher, M91	US ARMY USMC.	10,970	2,740		T2061VT
15	Warhead, M79, 762-mm (HONEST JOHN).	GB	Rocket, M31A1C Launcher, M386.	US ARMY USMC.	24,960	8,500		T2075 Mech Time
16	Warhead, E19R2, 762-mm (HONEST JOHN).	GB	Rocket, XM50 Launcher, M386.	US ARMY USMC.	33,830	8,500		T2075 Mech Time
17	Warhead, E19R2, 762-mm (HONEST JOHN).	VX	Rocket, XM50 Launcher, M386.	US ARMY USMC.	33,830	8,500		T2075 Mech Time
18	Warhead, E20, 318-mm (LITTLE JOHN).	GB	Rocket, XM51 Launcher, XM80.	US ARMY USMC.	18,290	3,200 [1]		T2075 Mech Time
19	Warhead, E21, (SERGEANT)	GB	Rocket, Launcher	US ARMY	139 km	50 km	304m	Preset Radar
20	Warhead, E21, (SERGEANT)	VX	Rocket, Launcher	US ARMY	139 km	50 km	304m	Preset Radar
21	Bomb, M34A1, 1000-lb, Cluster	GB	Fighter, Bomber	USAF	Range of Aircraft.		←Obtain from delivery unit→	M152E3 Mech Time
22	Bomb, MC-1, 750-lb	GB	Fighter, Bomber	USAF	Range of Aircraft.			M905BD
23	Projectile, 5"/38, MK53, MOD O	GB	5-inch Gun	US NAVY	16,450			MK29MOD3PD
24	Projectile, 5"/54, MK54, MOD O	GB	5-inch Gun	US NAVY	19,200			MK30MOD3PD
25	Warhead, Rocket, 5" MK40, MOD O.	GB	Launcher, MK 105 Rocket, M40, MOD O.	US NAVY	4,200			MK30MOD3PD
26	Warhead, Rocket, 5", MK40, MOD O.	HD	Launcher, MK 105 Rocket, M40, MOD O.	US NAVY	4,200			MK30MOD3PD
27	Bomb, MK94, MOD O	GB	Fighter, Bomber	US NAVY	Range of Aircraft.			AN-M103A1ND M195 BD (IMPACT).
28	Bomb, M70A1	HD	Fighter, Bomber	US NAVY	Range of Aircraft.			AN-M158ND (IMPACT).
29	Mine, Land, Chemical, M23	VX	N/A	US ARMY	N/A	N/A	N/A	
30	Mine, Land, Chemical, One-Gallon.	HD	N/A	US ARMY	N/A	N/A	N/A	

See notes at end of figure.

Figure 5. Chemical munitions and delivery systems.

5 Employment data—Continued						6 Functioning and physical characteristics of CML munitions				
(d)		(e)	(f)	(g)	(h)	(a)	(b)	(c)	(d)	(e)
Time for delivery		Organization	Rate of fire per weapon	Height of burst	Diameter (meters) of impact area (single rd) [2]	Weight of munition (kg)	Weight of agent (kg)	Effective weight of agent (kg) [3]	Functioning efficiency of munition (percent)	Agent dissemination efficiency
(1) Preplanned	(2) Target of opportunity									
		6 Mort/Plt 8 Mort/Btry	30 Rds/2 min 105 Rds/15 min	GND	16	10.8	2.72		99	
	1–3 min	6 How/Btry	6 Rds/½ min 18 Rds/4 min	GND	27	16.1	.739		99	
	1–3 min	6 How/Btry	6 Rds/½ min 18 Rds/4 min	GND	11	15.2	1.22		99	
	1–5 min	6 How/Btry	3 Rds/½ min 12 Rds/4 min	GND	49	45.9	2.95		99	
	1–5 min	6 How/Btry	3 Rds/½ min 12 Rds/4 min	GND	20	42.0	4.4		99	
	1–5 min	6 How/Btry	3 Rds/½ min 12 Rds/4 min	20m [1]		45.9	2.95		99	
	1–5 min	4 Gun/Btry	2 Rds/½ min 8 Rds/4 min	GND	49	45.9	2.95		99	
	1–5 min	4 Gun/Btry	2 Rds/½ min 8 Rds/4 min	GND	22	43.0	5.31			
		4 Gun/Btry		GND		66.8	6.68			
		4 Gun/Btry		GND		66.8	6.04			
	½–6 hr	4 How/Btry	6 Rds/4 min 10 Rds/10 min	GND	76	97.0	7.12		99	
	½–6 hr	4 How/Btry	6 Rds/4 min 10 Rds/10 min.	20m [1]		97.0	7.12		99	
	30 min	36 Lchr/Bn	45 Rkt/Lchr/15 sec	GND	46	26.4	4.80		99	
	30 min	36 Lchr/Bn	45 Rkt/Lchr/15 sec	20m [1]		26.2	4.54		99	
	15 min	2 Lchr/Bn	2/Hr	Variable	Variable	737	177.5	104.8	95	62 percent.
	15 min	2 Lchr/Btry	2/Hr	Variable	Variable	568	210	171	95	86 percent.
	15 min	2 Lchr/Btry	2/Hr	Variable	Variable	568	210			
	15 min	4 Lchr/Btry	2/Hr	Variable	Variable	119	30			
15 min	120 min	4 Lchr/Bn	2/Day	Intervals of 1,524m.	Variable	744	190			
15 min	120 min	4 Lchr/Bn	2/Day	Intervals of 1,524m.	Variable	744	190			
	15 min +flight time.		2–6/Ftr. 4–18/Bmbr.	Variable	170	513	89.6		90	
	15 min +flight time.		2–6/Ftr. 4–27/Bmbr.	GND	127	322	99.9			
				GND	35	25.1	1.47			
				GND	40	29.1	2.02			
			48 Rkt/Lchr/ 1 min	GND	49	22.9	2.18			
			48 Rkt/Lchr/ 1 min	GND						
				GND	90	222	49.8			
				GND	29	58.0	272			
						10.50	5.23			
						5.45	4.50			

[1] Estimated.
[2] Instantaneous agent area coverage 30 seconds after detonation.
[3] Values are the product of values given in columns 6(*b*), 6(*d*), and 6(*e*). Since values for 6(*e*) are not available, values for 6 (*c*)cannot be computed at this time.

Figure 5.—Continued

Agent—GB.
Wind speed—5 knots (approx 9 km/hr).
Temperature gradient—inversion.
Temperature—60° F. (15.5° C.).
Terrain—open, level, scattered vegetation.
Precipitation—none.
Time limitations on the delivery of agent on target—4 minutes or less.
Casualty level desired—20 percent.

Find: Whether or not the mission can be fired with a 105-mm howitzer battery.

Solution:

(*a*) Using figure 11, convert 20 percent casualties among protected personnel to the corresponding casualty level among unprotected personnel. This is 80 percent.

(*b*) Using the "GB (over 30-sec attack)" column of figure 12, determine the total effects components to be 3.21 as follows:

Inversion	1. 09
Wind speed, 9 km/hr	1. 00
Temperature, 60° F. (15.5° C.)	. 12
Open terrain	. 30
No precipitation	. 70
	3. 21

(*c*) Using figure 13, place a hairline between 80 percent on the percent casualties scale and 12 hectares on the target area scale. On the point of intersection on the reference line, pivot the hairline until it intersects 3.21 on the effects components scale. On the munitions expenditure scale, read 12 as the number of 155-mm equivalents required.

(*d*) To find the number of 105-mm rounds required to fire the mission, multiply 12 by a factor of four (obtain this factor from figure 8); the product is 48 rounds.

(*e*) From figure 9, it is evident that one battery of six howitzers can easily fire the mission if no shift of fires is required. Since the target is twice as large as the dispersion pattern of a 105-mm battery (par. 31*c*(3)(*c*) and 41*d*), a shift of fires should be made. Figure 9 gives a time of 30 seconds for shifting of fires. On this basis the battery could fire twenty-four rounds on half the target in a little less than 30 seconds, take 30 seconds to shift fires, and have ample time to deliver the remaining twenty-four rounds on the other half of the target. The firing should be completed in less than 2 minutes.

Munition	Munition expressed in terms of 155-mm chemical equivalents		
	GB	VX	HD
155-mm Shell	1	1	1
105-mm Shell	0. 25	--------	0. 28
8-inch Shell	2. 40	2. 17	--------
4.2-inch Mortar Shell	--------	--------	. 62
175-mm Shell	2. 1	2. 1	--------
M55 Rocket	1. 6	1. 6	--------
M79 Warhead—HONEST JOHN	60	--------	--------
E19R2 Warhead—HONEST JOHN	71	71	--------
LITTLE JOHN	10	10	--------
SERGEANT	65	65	--------
M34A1 1000-lb Cluster	30	--------	--------
MC1 750-lb Bomb	35	--------	--------
5″/38 Gas Projectile (Navy)	. 50	--------	--------
5″/54 Gas Projectile (Navy)	. 68	--------	--------
5″ Gas Rocket (Navy)	. 74	--------	--------
500-lb Gas Bomb	17	--------	--------
115-lb Gas Bomb (Navy)	--------	--------	6. 2

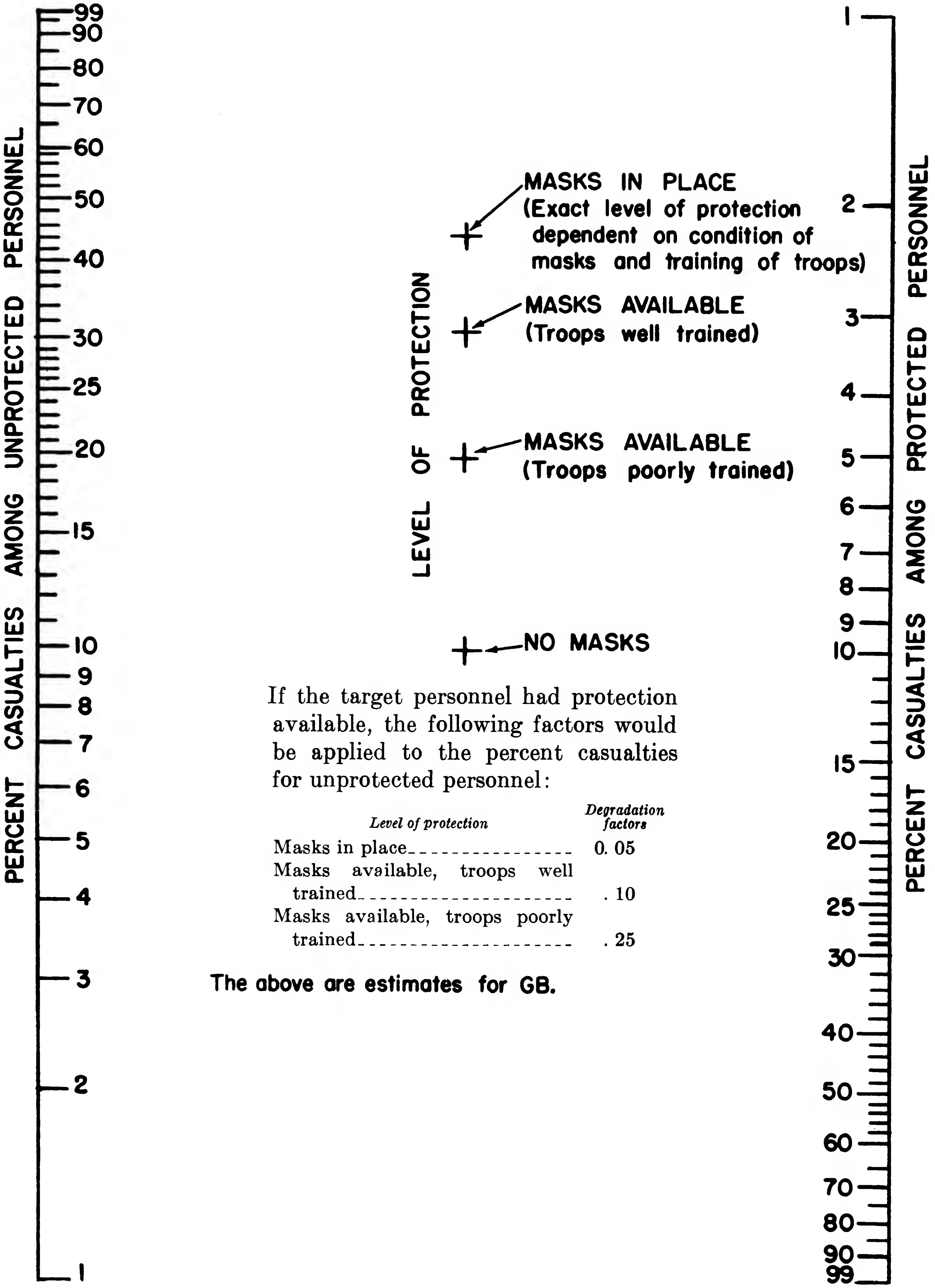
Figure 7. Munitions expressed in terms of 155-mm chemical equivalents. (The figures given are an estimate of the number of 155-mm howitzer rounds required to give the same effect as one round of the specified munition. Dissemination efficiency has not been considered.)

Munition	Conversion factor		
	GB	VX	HD
155-mm Shell	1	1	1
105-mm Shell	4	--------	3. 6
8-inch Shell	0. 41	0. 45	--------
4.2-inch Mortar Shell	--------	--------	1. 61
175-mm Shell	. 48	. 48	--------
M55 Rocket	. 61	. 61	--------
M79 Warhead—HONEST JOHN	. 017	--------	--------
E19R2 Warhead—HONEST JOHN	. 014	. 014	--------
LITTLE JOHN	. 098	. 098	--------
SERGEANT	. 016	. 016	--------
M34A1 1000-lb Cluster	. 033	--------	--------
MC1 750-lb Bomb	. 029	--------	--------
5″/38 Gas Projectile (Navy)	2. 00	--------	--------
5″/54 Gas Projectile (Navy)	1. 46	--------	--------
5″ Gas Rocket (Navy)	1. 35	--------	--------
500-lb Gas Bomb	. 059	--------	--------
115-lb Gas Bomb (Navy)	--------	--------	. 164

Figure 8. Conversion factors for converting 155-mm munitions to other munitions.

Weapon	Maximum rate (rounds)	Rates of fire for chemical fire missions without shifting or relaying of the piece (rounds)					Estimated time to shift fires
	30 sec	1 min	2 min	4 min	10 min	15 min	
105-mm Howitzer	6	10	14	18	40	60	30 sec
155-mm Howitzer	3	5	7	12	30	40	30 sec
155-mm Gun	2	4	6	8	12	18	60 sec
8-inch Howitzer	1	2	3	6	10	15	60 sec
4.2-inch Mortar	10	16	30 (max)	50	80	105	30 sec
M91 Launcher (M55 Rocket)	45 (15 sec)	Launcher must relocate after firing each ripple.					

Figure 9. Approximate rates of fire for division cannon artillery, mortars, and multiple rockets firing chemical rounds. (Rates of fire for other weapons are given in figure 5.)



If the target personnel had protection available, the following factors would be applied to the percent casualties for unprotected personnel:

Level of protection	*Degradation factors*
Masks in place	0.05
Masks available, troops well trained	.10
Masks available, troops poorly trained	.25

The above are estimates for GB.

Figure 11. Nomogram for conversion of percent GB casualties for protection of personnel in the target area.

Meteorological and terrain conditions	Effects components			
	GB [2] (surprise attack)	GB (over 30-sec attack)	VX	HD
1. *Temperature Gradient*				
Inversion	0.67	1.09	1.89	0.69
Neutral	.57	.69	1.89	.54
Lapse	.30	.09	1.89	.32
2. *Wind Speed (km/hr)*				
0 to 5	.20	1.30	0	.87
6 to 10	.50	1.00	0	.70
11 to 16	.70	.70	0	.60
17 to 26	.55	.30	0	.48
27 to 52	.30	0	0	0
3. *Temperature (° F.)*				
a. 0 to 39 (−18° to 4° C.)	0	0	0	----------
40 to 79 (5° to 26° C.)	.12	.12	0	----------
80 and up (27° C. and up)	.23	.23	0	----------
b. 30 to 49 (−1° to 9° C.)	----------	----------	0	0
50 to 69 (10° to 21° C.)	----------	----------	0	.70
70 and up (22° C. and up)	----------	----------	0	1.00
4. *Terrain*				
Open, level, scattered vegetation	.30	.30	0	.30
Rugged, mountainous	0	[1] 0	[1] 0	[1] 0
5. *Precipitation*				
None	.70	.70	.70	0
Moderate rain	0	[1] 0	[1] 0	[1] 0

[1] Estimated.
[2] Tentative figures not yet verified.

Figure 12. Effects components.

Note: paragraph 105 on page 82 states that the "safe entry times" after bio attacks are:

NU (Venezuelan equine encephalitis virus),
AB (bovine brucellosis), and
UL (tularemia): 2 hrs sun or 8 hrs cloudy
OU (Q fever): 2 hrs sun or 18 hrs cloudy

Cloudy conditions also apply to nighttime

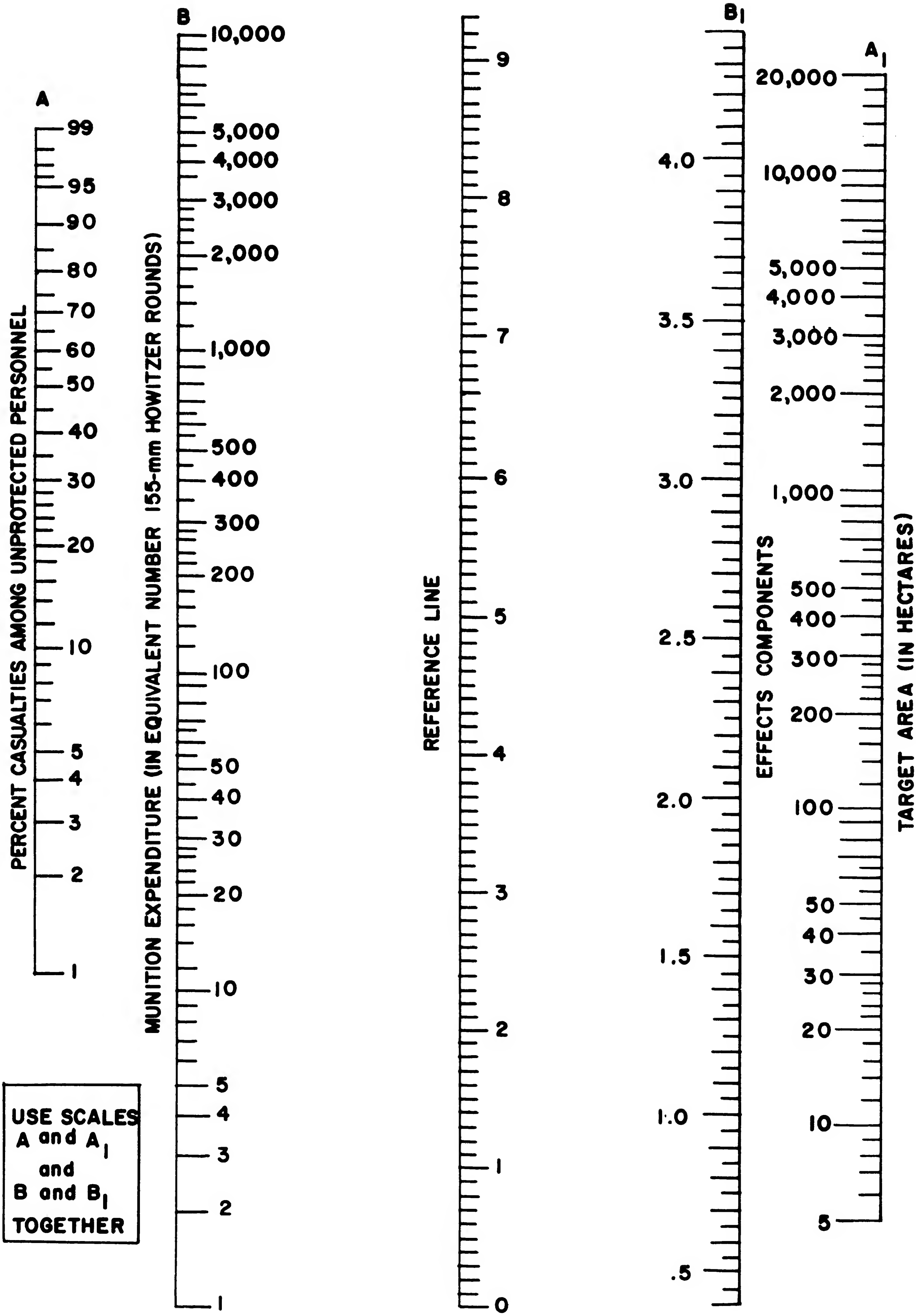


Figure 13. Target area, casualty level, munitions requirement nomogram.

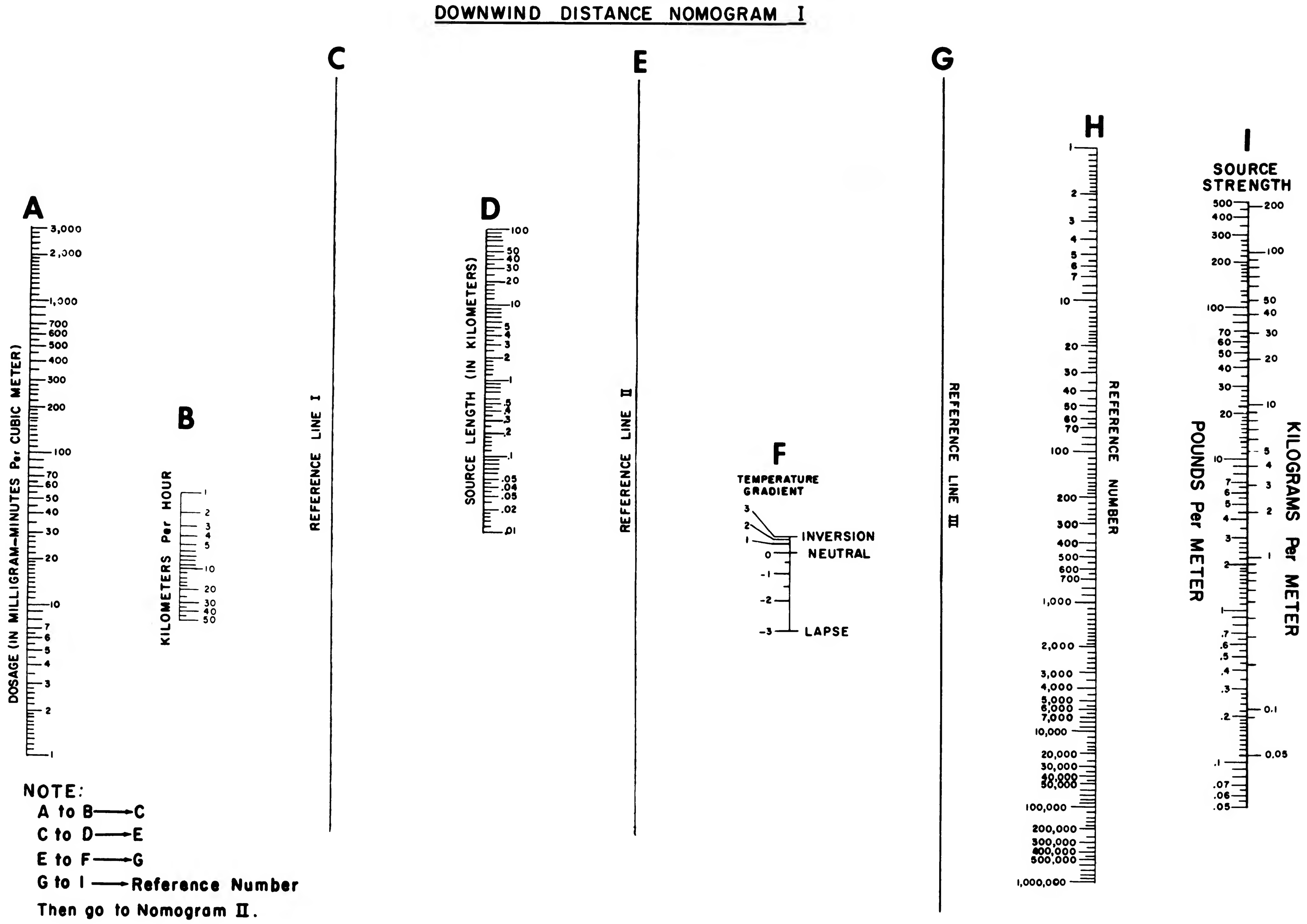


Figure 14. Downwind distance nomogram I.

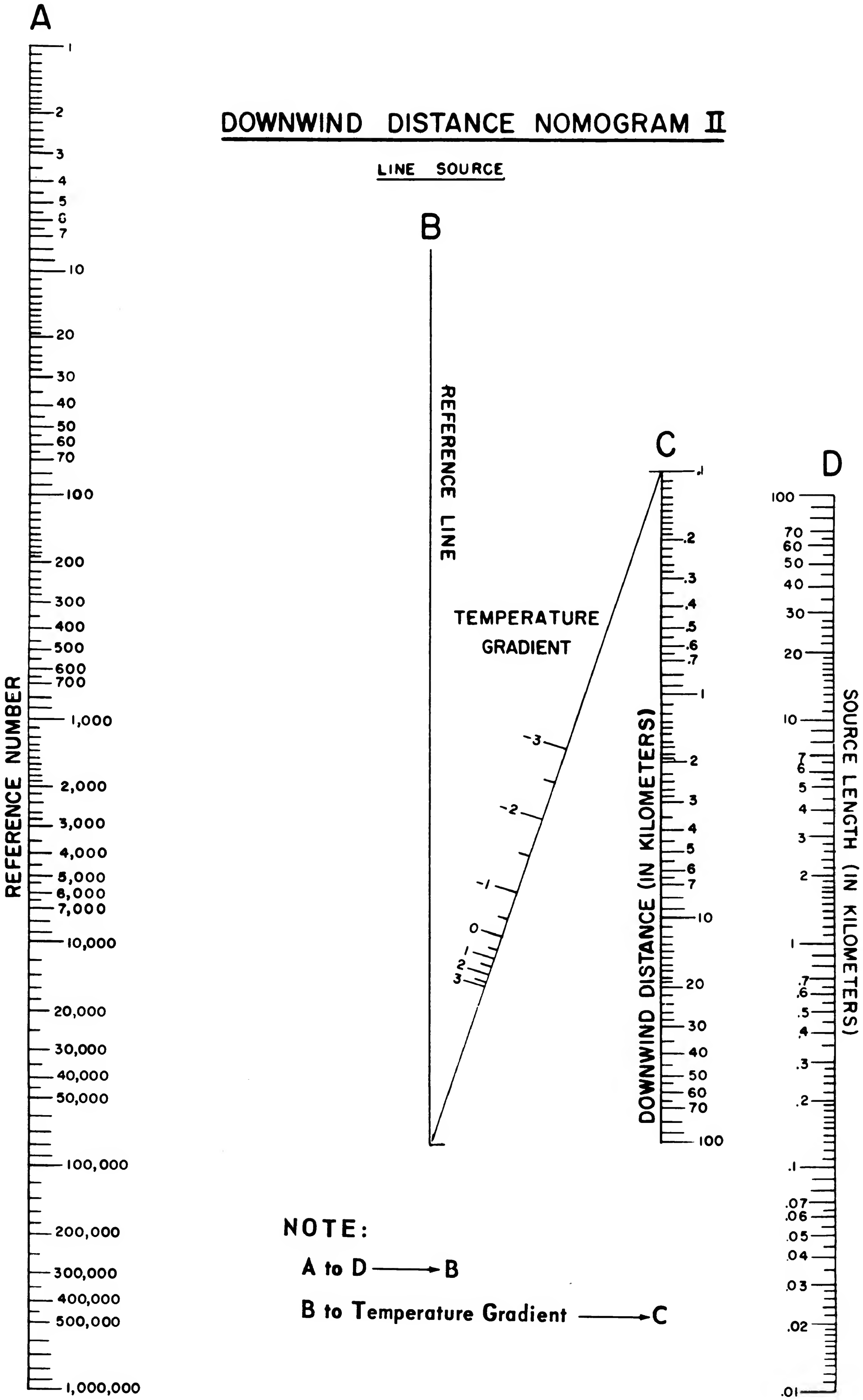


Figure 15. Downwind distance nomogram II.

USACGSC RB 3-1

REFERENCE BOOK

CHEMICAL AND BIOLOGICAL WEAPON EMPLOYMENT

U.S. ARMY COMMAND AND GENERAL STAFF COLLEGE
Fort Leavenworth, Kansas

1 May 1968

This reference book supersedes RB 3-1, 1 May 1967

CHAPTER 2
TOXIC CHEMICAL AGENTS

1. Characteristics and Effects

a. General. The following antipersonnel chemical agents are used for College instruction in chemical weapon employment: nerve agents GB and VX; blister agent HD (mustard); and incapacitating agent BZ. Actual or assumed characteristics of these agents are described in the following paragraphs for instructional purposes only and are summarized in figure 1.

b. Nerve Agent GB. GB is a quick acting, nonpersistent lethal agent that produces casualties primarily by inhalation.

(1) Inhalation effects. Inhaled GB vapor can produce casualties within minutes. As an example, 50 percent of a group of unprotected troops engaged in mild activity, breathing at the rate of about 15 liters per minute, and exposed to 70 milligrams of GB per cubic meter of air for 1 minute will probably die if they do not receive medical treatment in time. This is the median lethal dosage (50) and is expressed as 70 mg-min/m^3. For troops engaged in activities that increase their breathing rate, the median lethal dosage can be as low as 20 mg-min/m^3. The median incapacitating dosage of GB vapor by inhalation is about 35 mg-min/m^3 for troops engaged in mild activity. Incapacitating effects consist of nausea, vomiting, diarrhea, and difficulty with vision, followed by muscular twitching, convulsions, and partial paralysis. Dosages of GB less than the median incapacitating dosage cause general lowering of efficiency, slower reactions, mental confusion, irritability, severe headache, lack of coordination, and dimness of vision due to pinpointing of the eye pupils.

(2) Percutaneous effects. Percutaneous effects refer to those effects produced by the absorption of the agent through the skin. GB vapor absorbed through the skin can produce incapacitating effects. Sufficient GB liquid absorbed through the skin can produce incapacitation or death. The effectiveness of the liquid or vapor depends on the amount absorbed by the body. Absorption varies with the original amount of agent contamination, the skin area exposed and the exposure time, the amount and kind of clothing worn, and the rapidity in removing the contamination and/or contaminated clothing and in decontaminating affected areas of the skin.

(3) Major considerations in the employment of nerve agent GB. The employment of GB is based primarily on achieving casualties by inhalation of the nonpersistent vapor (or aerosol) of the agent. Major considerations in the employment of this agent are:

(a) Time to incapacitate. The onset of incapacitation resulting from inhalation of casualty-producing doses is rapid, the average time being approximately 3 minutes. To allow for the time required for the agent cloud to reach the individual, 10 minutes is used as the mean time to achieve incapacitation. Nonlethal casualties from GB will be incapacitated for 1 to 5 days.

(b) Persistency. Persistency is defined as the length of time an agent remains effective in the target area after dissemination. Nerve agent GB is considered nonpersistent. GB clouds capable of producing significant casualties will dissipate within minutes after dissemination. Some liquid GB will remain in chemical shell or bomb craters for periods of time varying from hours to days, depending on the weather conditions and type of munition. Because of this continuing but not readily discernible threat, GB can also be highly effective in harassing roles by causing exposure to low concentrations of the vapor. Rounds fired sporadically may compel the enemy to wear protective masks and clothing for prolonged periods, thereby impairing his effectiveness as a result of fatigue, heat stress, discomfort, and decrease in perception.

(c) Level of protection. The weapon system requirements for positive neutralization of masked personnel by GB are too great to be supported except for important point or small area targets. A major factor affecting casualties resulting from GB attacks of personnel equipped with masks but unmasked at the time of attack is the time required for enemy troops to mask after first detecting a chemical attack. Therefore, surprise dosage attack is used to establish a dosage sufficient to produce the desired casualties before troops can mask. Casualty levels for surprise dosage attack that are tabulated in the weapon system effects tables (app A) are based on an assumed enemy masking time of 30 seconds. (Refer to FM 3-10 series manuals for operational data for masking times less than 30 seconds.) A total dosage attack is used to build up the dosage over an extended period of time and is normally employed against troops who have no protective masks available. Dosages built up before troops can mask inside foxholes, bunkers, tanks, buildings, and similar structures will generally be less than dosages attained during the same period of time in the open, thereby reducing the effects on occupants from surprise dosage attacks. Total dosage effects are essentially the same inside or outside.

c. Nerve Agent VX. VX is a slow-acting, lethal, persistent agent that produces casualties primarily by absorption of droplets through the skin.

(1) Effects. VX acts on the nerve systems of man; interferes with breathing; and causes convulsions, paralysis, and death.

(2) Major considerations in the employment of nerve agent VX.

(a) General. Agent VX disseminated in droplet (liquid) form provides maximum duration of effectiveness as a lethal casualty threat. VX will remain effective in the target area for several days to a week depending on weather conditions. Because of its low volatility, there is no significant vapor hazard downwind of a contaminated area. Except when disseminated by aircraft spray tanks, meteorological conditions have little effect on the employment of VX, although strong winds may influence the distribution of the agent and heavy rainfall may wash it away or dissipate it.

(b) Employment to cause casualties. Agent VX is appropriate for direct attack of area targets containing masked personnel in the open or in foxholes without overhead protection, for causing severe harassment by the continuing casualty threat of agent droplets on the ground or on equipment, and for creating obstacles to traversing or occupying areas. Casualties produced by agent VX are delayed, occurring at times greater than 1 hour after exposure. Although this agent can be used relatively close to friendly forces, it should not be used on positions that are likely to be occupied by friendly forces within a few days. Because of this continuing hazard, areas in which agent VX has been used should be recorded in a manner similar to minefields or fallout areas so that necessary precautions can be taken.

d. Blister Agent HD. HD, sometimes referred to as mustard, is a persistent slow-acting agent that produces casualties through both its vapor and liquid effects.

(1) Vapor effects.

(a) The initial disabling effect of HD vapor on unmasked troops will be injuries to the eyes. Temporary blindness can be caused by vapor dosages that are insufficient to produce respiratory damage or skin burns. However, skin burns account for most injuries to masked troops. The vapor dosages and the time required to produce casualties (4 to 24 hours) vary with the atmospheric conditions of temperature and humidity and with the amount of moisture on the skin. Depending on their severity, skin burns can limit or entirely prevent movement of the limbs or of the entire body.

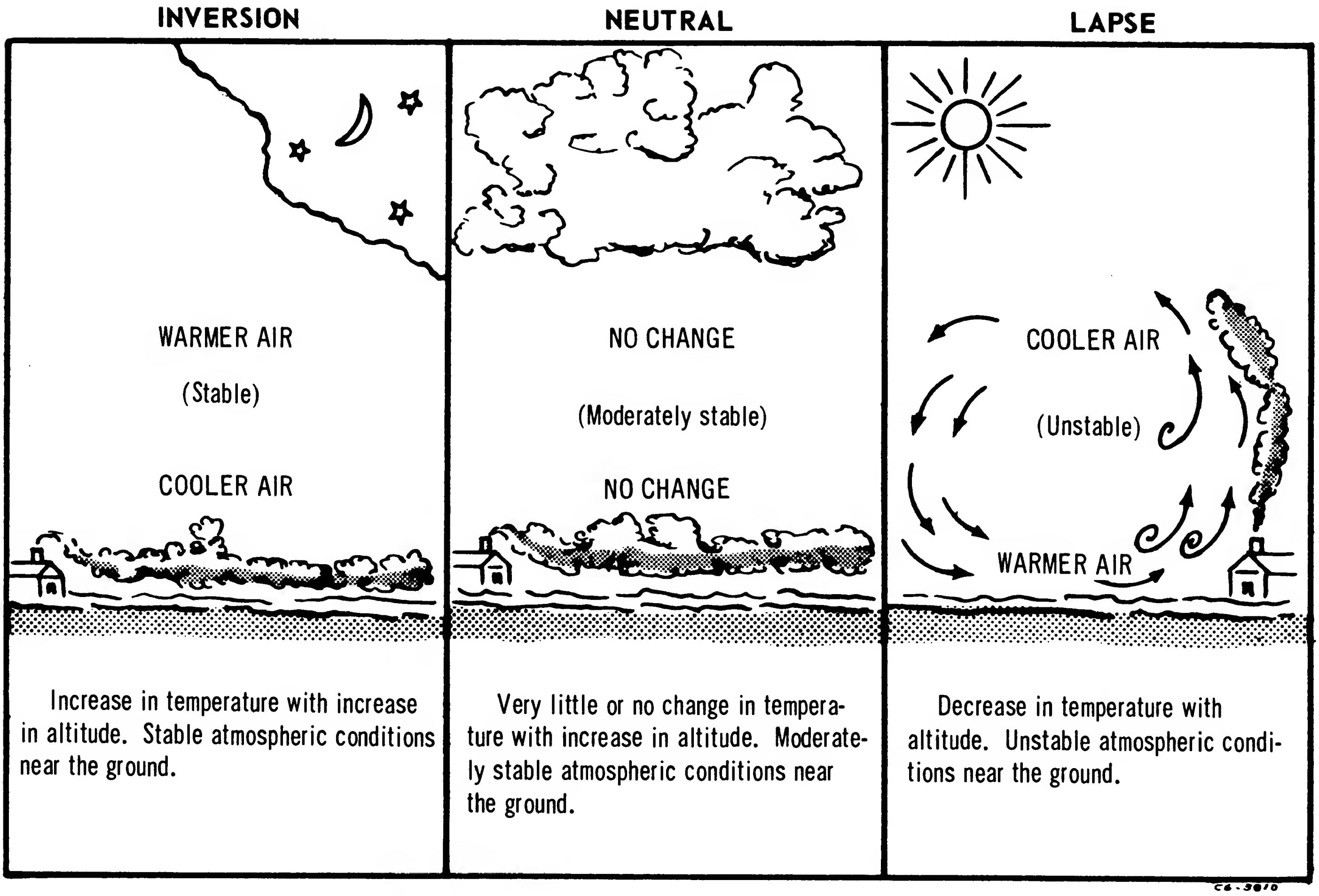


Figure 2. Temperature gradients.

Surprise dosage GB attacks are influenced only slightly by the temperature gradient except when made with the spray tank. Downwind vapor hazards to both enemy and friendly forces will be most significant during inversion and neutral conditions. Employment of VX is not affected by the temperature gradient.

Temperature gradients	Time
1. Inversion	From sunset to sunrise.
2. Neutral	2 hours before sunset to sunset, sunrise to 2 hours after sunrise, or any time windspeed is 15 kmph or greater.
3. Lapse	2 hours after sunrise to 2 hours before sunset.

Figure 3. Estimated times that temperature gradients will prevail. (Use when meteorological data are not available.)

(3) When actual or predicted meteorological conditions are not available for a target analysis, 70° F is used for temperature, 9 kmph is used as windspeed, and the temperature gradient is approximated from figure 3.

d. Windspeed and Direction.

(1) Air moving over the earth's surface sets up eddies, or mechanical turbulences, that act to dissipate a chemical cloud. A condition of calm will limit the merging of the individual gas clouds. Both of these conditions may reduce the effectiveness of a chemical agent attack. High winds increase the rate of evaporation of HD and dissipate chemical clouds more rapidly than low winds. Moderate winds are desirable for chemical employment. Large-area nonpersistent chemical attacks are most effective in winds not exceeding 28 kmph. Small-area nonpersistent chemical attacks with rockets or shell are most effective in winds not exceeding 9 kmph. However, if the concentration of chemical agent can be established quickly, the effects of high windspeed can be partially offset.

CHAPTER 4
EMPLOYMENT OF BIOLOGICAL AGENTS

1. General

a. Antipersonnel biological agents are micro-organisms that produce disease in man. These agents can be used to incapacitate or kill enemy troops through disease. They may cause large numbers of casualties over vast areas and could require the enemy to use many personnel and great quantities of supplies and equipment to treat and handle the casualties. Many square kilometers can be effectively covered from a single aircraft or missile. The search capability of biological agent clouds and the relatively small dose required to cause infection among troops give biological munitions the capability of covering large areas where targets are not precisely located.

b. A biological attack can occur without warning since biological agents can be disseminated by relatively unobtrusive weapon systems functioning at a considerable distance from the target area and relying upon air movement to carry the agent to the target.

c. Biological agents do not produce effects immediately. An incubation period is required from the time the agent enters the body until it produces disease. Some agents produce the desired casualty levels within a few days, whereas others may require more time to produce useful casualty levels. A variety of effects may be produced, varying from incapacitation with few deaths to a high percentage of deaths, depending on the type of agent.

2. Methods of Dissemination

a. The basic method of disseminating antipersonnel biological agents is the generation of aerosols by explosive bomblets and spray devices. Because exposure to sunlight increases the rate at which most biological agent aerosols die and thereby reduces their area coverage, night is the preferable time for most biological attacks. However, if troop safety is a problem, an attack may be made near sunrise to reduce the distance downwind that a hazard to friendly forces will extend. Conversely, to extend the downwind cloud travel and the area coverage from spray attack, a biological agent may be employed soon after sundown.

b. Missile-delivered Biological Munitions. Missile-delivered biological munitions are used for attack of large-area targets. A typical biological missile system consists of the following components:

(1) A missile vehicle and its launching equipment.

(2) A warhead that can be opened at a predetermined height to release biological bomblets over the target area. The warhead is shipped separately for assembly to a missile at the launching site.

(3) A warhead shipping container equipped with a heating-cooling element and a temperature control unit.

(4) Biological bomblets consisting of an agent container and a central burster that functions on impact. The bomblets have vanes that cause them to rotate in flight, thereby achieving lateral dispersion during their free fall and resulting in random distribution as a circular pattern.

c. Aircraft Spray Tank. Biological agents released from an aircraft spray tank cover a large area downwind of the line of release. A typical spray tank consists of the following components:

(1) An agent reservoir section that is shipped separately in an insulated shipping and storage container equipped with a heating-cooling element and a temperature control unit.

(2) A discharge nozzle assembly that can be mechanically adjusted to vary the agent flow rate.

Table 1. Chemical Weapons Data

1	2	3	4	5	6	7	8	9	10	11	12	13
Delivery system	Range (meters)		Agent	Munition	No of weapons per delivery unit	Weapon rate of fire	RT max (meters)[1 2]					Reference (table)
							Fire unit	Total dosage Casualty threat		Surprise dosage Casualty threat		
	Min	Max						10%	30%	10%	30%	
4.2-in mortar	180	4,500	HD	Cartridge, M2A1	4/Plat	50 rd/3 min 105 rd/15 min						18 19
105-mm howitzer		11,100	GB	Cartridge, M360	6/btry	5 rd/30 sec	1 btry[3]	200	100	100	50	2
						30 rd/3 min	1 bn[3]	300	300	200	100	3
			HD	Cartridge, M60		66 rd/15 min						18 19
155-mm howitzer		14,600	GB	Projectile, M121	6/btry	2 rd/30 sec	1 btry[3]	300	200	100	0	4
						12 rd/3 min	1 bn[3]	500	400	300	100	5
			HD	Projectile, M110		24 rd/15 min						18 19
			VX[4]	Projectile, M121			1 btry[3]	400	200	NA	NA	13
							1 bn[3]	500	400			
8-in howitzer		16,800	GB	Projectile, M426	4/btry	1 rd/30 sec	1 btry[3]	300	200	200	0	6
						4 rd/3 min	1 bn[3]	500	400	300	100	7
			VX[4]			10 rd/15 min	1 btry[3]	400	200	NA	NA	14
							1 bn[3]	500	400			
115-mm multiple rocket launcher, M91	2,740	10,600	GB[4]	Rocket, M55 (THE BOLT)		45 rkt/lchr/15 sec	1 lchr	1,000	750	500	200	8
							3 lchr	1,000	1,000	750	400	
							6 lchr	1,000	1,000	1,000	750	
							9 lchr	1,000	1,000	1,000	1,000	
			VX[4]				1 lchr	300	0	NA	NA	15
							3 lchr	750	300			
							6 lchr	1,000	400			
							9 lchr	1,000	750			
762-mm rocket, Honest John	8,500	38,000	GB[4]	Warhead, M190 (M139 bomblets)	2/btry	2 rkt/lchr/hr	1 lchr	600	600	600	400	9
							2 lchr	600	600	600	400	
Sergeant missile	46,000	139,000	GB[4]	Warhead, M212 (M139 bomblets)	2/bn	2 msl/lchr/hr	1 msl	600	400	600	200	10
							2 msl	600	600	600	400	
Aircraft	Dependent on type aircraft		GB[4]	Bomb, MC-1, 750-lb		Dependent on type aircraft	1 bomb	50				11
							6 bombs	300	200	300	50	
							12 bombs	500	300	400	200	
							24 bombs	500	300	500	300	
			GB[4]	Spray tank, 100-gal			1 spray tank 2 spray tanks	RT max=750 meters (one-half effective spray release line length)				12
			VX[4]				1 spray tank	RT max=500 meters (one-half effective spray release line length)				16
			BZ[4]	Bomb, 150-lb Bomb, 700-lb								17

[1]RT max is largest target radius for which indicated casualty threat is tabulated for appropriate fire unit. Division of target into subtargets NOT considered.

[2]All windspeeds, temperature gradients, and protection categories considered.

[3]RT max computed for maximum number of volleys for which data are tabulated.

[4]Weapon system capabilities derived from tables composed of hypothetical data for INSTRUCTIONAL PURPOSES ONLY at the U. S. Army Command and General Staff College. For actual data, refer to FM 3-10.

Table 2. Estimated Fractional Casualty Threat From 105-mm Howitzer, GB Projectile, Battery Fire[1 2]

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Target radius–radius of effect (meters)	Range to target (km)	No of volleys	Windspeed[3]											
			4 kmph				9 kmph				28 kmph			
			Surprise[4]	Total dose[5]			Surprise[4]	Total dose[5]			Surprise[4]	Total dose[5]		
				I	N	L		I	N	L		I	N	L
50	<7.5	1	.10	.25	.20	.15	.10	.15	.10	.10				
		2	.20	.45	.40	.30	.15	.30	.25	.20		.10	.05	.05
		3	.30	.60	.60	.35	.30	.50	.45	.30	.10	.20	.15	.10
		4	.30	.75	.70	.45	.30	.55	.45	.35	.10	.25	.20	.10
		5	.35	.90	.85	.55	.35	.60	.50	.40	.15	.30	.25	.15
	>7.5	1	.05	.15	.15	.10	.05	.10	.05	.05				
		2	.15	.30	.25	.15	.10	.20	.15	.10		.05	.05	
		3	.15	.30	.30	.25	.10	.20	.20	.15		.10	.05	.05
		4	.20	.40	.35	.25	.15	.30	.30	.15	.05	.15	.15	.05
		5	.25	.45	.45	.30	.25	.40	.35	.25	.10	.20	.20	.10
100	<7.5	1	.05	.15	.15	.10	.05	.10	.05	.05				
		2	.10	.30	.30	.15	.10	.20	.15	.10				
		3	.15	.40	.35	.20	.15	.25	.25	.15	.05	.10	.05	
		4	.15	.40	.35	.30	.15	.30	.30	.15	.05	.10	.10	.05
		5	.20	.45	.40	.35	.20	.35	.35	.20	.10	.15	.15	.10
	≥7.5	1	.05	.10	.10	.05		.05	.05					
		2	.10	.20	.20	.10	.05	.15	.10	.05				
		3	.10	.25	.25	.15	.10	.15	.15	.10		.05	.05	
		4	.10	.30	.25	.20	.10	.25	.20	.15		.10	.05	
		5	.15	.35	.30	.25	.15	.30	.25	.15	.05	.15	.10	.05
200	Any	1		.05	.05									
		2		.10	.10	.05		.05	.05					
		3	.05	.15	.15	.05		.10	.05					
		4	.05	.15	.15	.10		.10	.10					
		5	.05	.20	.20	.10	.05	.15	.10	.05				

[1] Blank spaces indicate fractional casualties are below 0.05.

[2] If the target is predominately wooded, use a windspeed of 4 kmph and neutral temperature gradient for total dose attack; use a windspeed of 4 kmph for surprise attack.

[3] For windspeeds other than those shown, use data given for the nearest windspeed.

[4] Multiply the figures given in the table by the appropriate factor to obtain the fractional casualties from surprise dose attack:

Troops in open foxholes:	0.7
Troops in covered foxholes or bunkers:	0.6

[5] I=inversion, N=neutral, L=lapse.

Table 17. BZ Munitions Requirements

1	2	3	4	5	6
Munition	Casualty level[2]	Area coverage[1] (square kilometers)			
		Windspeed[3]			
		8 kmph		16 kmph	
		Temperature gradient		Temperature gradient	
		Inversion	Neutral	Inversion	Neutral
150-lb bomb	.40 .75	.05 .03	.02 .01	.03 .02	.01 .009
700-lb bomb	.40 .75	.20 .10	.07 .04	.09 .05	.04 .03

[1]Area coverages are for one bomb.

[2]Casualty levels are for personnel without masks available. For personnel with masks available, multiply casualty levels by 0.7.

[3]For windspeeds other than those shown, use data given for the nearest windspeed.

NOTE: The above table is composed of hypothetical munitions and data for INSTRUCTIONAL PURPOSES ONLY at the U. S. Army Command and General Staff College. For actual data, refer to FM 3-10.

Table 18. HD Ammunition Expenditure for Vapor Effect (50 Percent Coverage of Target Area)[1] [2]

Rounds required per hectare

Desired effect[3]	Exposure time (hours) — Temperature (°F) 55°	70°	85°	100°	4.2-inch mortar (cartridge M2A1) — Windspeed (kmph) 6 — Temperature gradient[4] I	6 N	6 L	9 I	9 N	9 L	15 I	15 N	15 L	26 I	26 N	26 L
Cause eye irritation to troops without masks.	1	½	¼	⅛	10	14	16	11	21	22	15	22	26	20	24	29
	2	1	½	¼	6	8	9	8	12	14	12	13	16	17	21	24
	4	2	1	½	6	6	8	8	9	10	9	10	13	13	16	20
	8	4	2	1	4	6	6	6	8	9	8	9	11	12	13	15
	16	8	4	2	4	5	5	5	8	9	8	8	10	10	11	13
Disable masked troops (sweating in humid weather).	1	½	¼	⅛	35	46	52	39	53	63	46	63	80	59	77	108
	2	1	½	¼	20	29	33	24	35	40	30	45	56	41	59	69
	4	2	1	½	15	21	24	17	27	33	24	35	42	30	47	65
	8	4	2	1	11	17	18	13	21	26	17	28	38	27	45	63
	16	8	4	2	9	14	16	11	18	22	16	24	33	24	42	58
Disable masked troops (dry weather).	1	½	¼	⅛	64	83	95	72	95	114	86	113	144	108	144	198
	2	1	½	¼	36	52	58	44	62	72	57	81	101	71	120	125
	4	2	1	½	26	35	41	30	46	56	45	62	76	57	86	119
	8	4	2	1	18	27	30	23	35	44	32	50	68	50	81	114
	16	8	4	2	13	21	26	18	30	40	29	46	60	42	72	108

Desired effect[3]	Exposure time (hours) — Temperature (°F) 55°	70°	85°	100°	105-mm howitzer (cartridge M60) — Windspeed (kmph) 6 — Temperature gradient[4] I	6 N	6 L	9 I	9 N	9 L	15 I	15 N	15 L	26 I	26 N	26 L
Cause eye irritation to troops without masks.	1	½	¼	⅛	22	24	27	24	34	39	39	44	46	32	53	65
	2	1	½	¼	18	22	23	20	22	27	29	32	34	26	39	51
	4	2	1	½	16	17	20	17	18	20	20	22	24	22	29	39
	8	4	2	1	12	15	17	13	12	17	15	20	22	18	27	36
	16	8	4	2	10	12	13	10	11	15	12	17	20	15	24	34
Disable masked troops (sweating in humid weather).	1	½	¼	⅛	70	83	108	77	95	121	95	123	166	108	157	243
	2	1	½	¼	42	54	63	47	63	84	66	89	102	82	108	192
	4	2	1	½	27	36	45	32	47	62	48	64	84	64	88	162
	8	4	2	1	18	29	34	24	38	47	33	53	76	54	83	138
	16	8	4	2	15	23	27	18	32	42	30	51	66	48	72	120
Disable masked troops (dry weather).	1	½	¼	⅛	128	154	174	144	174	212	189	...	...	202	...	...
	2	1	½	¼	75	98	128	89	113	147	111	156	180	148	198	288
	4	2	1	½	50	64	81	59	86	111	88	118	153	117	165	256
	8	4	2	1	33	50	58	45	65	84	62	95	138	101	154	240
	16	8	4	2	26	39	45	34	56	72	54	84	120	84	132	193

Desired effect[3]	Exposure time (hours) — Temperature (°F) 55°	70°	85°	100°	155-mm howitzer and gun (projectiles M110 and M104) — Windspeed (kmph) 6 — Temperature gradient[4] I	6 N	6 L	9 I	9 N	9 L	15 I	15 N	15 L	26 I	26 N	26 L
Cause eye irritation to troops without masks.	1	½	¼	⅛	8	10	10	9	11	12	10	12	13	11	14	16
	2	1	½	¼	6	8	9	8	10	11	9	11	12	10	12	14
	4	2	1	½	4	5	6	6	8	9	8	9	10	9	10	12
	8	4	2	1	4	5	5	5	6	8	6	8	9	8	9	11
	16	8	4	2	4	4	4	4	5	6	5	6	8	5	8	10
Disable masked troops (sweating in humid weather).	1	½	¼	⅛	20	28	30	23	32	36	26	39	44	32	46	58
	2	1	½	¼	12	17	20	15	22	24	18	27	34	24	36	46
	4	2	1	½	10	13	16	11	18	20	15	20	27	18	29	33
	8	4	2	1	6	10	12	9	13	16	12	17	24	16	23	33
	16	8	4	2	5	9	11	8	11	15	11	15	22	15	20	29
Disable masked troops (dry weather).	1	½	¼	⅛	36	48	53	41	56	63	46	66	78	59	83	105
	2	1	½	¼	21	28	33	26	36	41	38	54	63	42	65	84
	4	2	1	½	15	21	26	18	28	33	26	36	45	33	50	66
	8	4	2	1	11	16	18	13	21	26	22	33	40	28	42	56
	16	8	4	2	9	12	15	11	18	21	18	30	36	24	38	46

[1]For open terrain. For heavily wooded terrain or jungle, multiply the figure obtained by 0.5 to obtain the appropriate expenditure.

[2]Blank spaces indicate excessive expenditures.

[3]An average of 50 percent casualties is expected among all troops who remain in the target area for the times specified.

[4]I = inversion, N=neutral, L=lapse.

[redacted]

S/C

DEPARTMENT OF THE ARMY FIELD MANUAL	FM 3–10B
NAVAL WARFARE INFORMATION PUBLICATION	NWIP 36–4
DEPARTMENT OF THE AIR FORCE MANUAL	AFM 355–9
MARINE CORPS MANUAL	FMFM 11–3B

EMPLOYMENT OF CHEMICAL AGENTS (U)

This copy is a reprint which includes current pages from Changes 1.

[redacted]

[redacted]

DEPARTMENTS OF THE ARMY, THE NAVY AND THE AIR FORCE
NOVEMBER 1966

[redacted]

6. ~~(C)~~ (U) Incapacitating Agent BZ

This agent is disseminated as an aerosol to produce physical and mental effects when inhaled. The effects are temporary, and recovery is normally complete. There may be permanent ill effects in a few instances among the very young, the aged, and the infirm, or when massive dosages are received.

a. Tactical Employment. BZ is employed against carefully selected targets to incapacitate enemy troops when the use of lethal or destructive munitions is undesirable. This agent may be particularly useful in situations where adequate protective equipment is normally not available to enemy troops or where the status of training or mask discipline is poor, such as in counterinsurgency operations.

b. Limitations. BZ has the following limitations:

(1) The white agent cloud produced by pyrotechnic mixtures acts as a visible alarm.

(2) BZ may be defeated by improvised respiratory protection such as a folded cloth over mouth and nose.

(3) The effects are not immediate but require an average onset time of about 3 to 6 hours.

(4) There is no known antidote to treat affected friendly personnel.

c. Median Incapacitating Dosage (ICt_{50}). This is about 110 mg-min/m³ for man engaged in mild activity (breathing rate of 15 liters/min).

d. Physiological and Psychological Symptoms. The symptoms listed below will become more intense as the dosage received increases. They also vary according to the inherent characteristics of each individual exposed to the agent. Because of the many variables involved, estimation of the percentage and type of casualties produced from a BZ attack is difficult. Approximations for the occurrence of ultimate casualties among unmasked personnel are 5 percent in 2 hours, 50 percent in 4½ hours, and 95 percent in 9½ hours.

(1) Symptoms likely to appear in 30 minutes to 3 hours: dizziness, extreme drowsiness, dryness of the mouth, and increased heartbeat.

(2) Symptoms likely to appear in 3 to 5 hours: restlessness, involuntary muscular movement, near vision impairment, and physical incapacitation.

(3) Symptoms likely to appear in 6 to 10 hours: hallucinations, lack of muscular coordination, disorientation, and difficulty in memory recall.

e. Duration of Incapacitation. The duration of incapacitation varies with the dosage received—from 24 hours to 5 days.

f. Duration of Effectiveness. Under average meteorological conditions in the open, the aerosol is normally effective for only a few minutes after dissemination, since the fine BZ particles travel

[redacted]

27. (U) CBU-5B/M43 750-Pound BZ Cluster Bomb

Both the U.S. Air Force CBU-5B and the U.S. Army M43 750-pound cluster bombs contain 57 M138 BZ-filled bomblets. The U.S. Army M43 cluster is designed for delivery by aircraft at low speeds. When modified and equipped with a suitable fairing for streamlining purposes, an internal arming wire system, and a strengthened tail fin, it is then designated the CBU-5B and can be delivered by high-performance aircraft.

a. Operational Concepts. The BZ cluster bomb is used on carefully selected targets against enemy personnel when the use of lethal chemical or destructive weapon systems is militarily or politically undesirable. See paragraph 6 for additional data.

b. Characteristics. The cluster contains about 85 pounds of agent BZ and employs two tail mechanical time fuzes. To function properly, the cluster must be released above 6,200 feet so as to allow the cluster to open at approximately 4,500 feet. The M138 bomblet contains four canisters, each with three-fourth pound of agent-pyrotechnic mixture (50/50 ratio), and an "all-ways" impact fuze. The bomblet is *not* self-dispersing.

c. Capabilities. The cluster delivers M138 bomblets over an elliptical impact area having a cross section of approximately 100 by 200 meters when released at heights above 6,200 feet. One cluster can cover about 12,000 square meters (1.2 hectares) with an incapacitating total dosage of BZ (110 mg-min/m^3) under neutral temperature gradient and in a wind speed between 2 and 10 knots; under lapse temperature gradient conditions, the area coverage will be smaller. Under optimum delivery conditions, the area coverage for one cluster is expected to range from 15,000 to 20,000 square meters. Field tests indicate that wind speed has only minor effects upon area coverage.

d. Operational Considerations. Refer to the appropriate technical order/flight manual to determine aircraft loads (see para 16*d*).

 [redacted]

Field Manual
No 3-6

Air Force Manual
No 105-7

Fleet Marine Force Manual
No. 7-11-H

HEADQUARTERS
DEPARTMENT OF THE ARMY
DEPARTMENT OF THE AIR FORCE
UNITED STATES MARINE CORPS
Washington, DC, 3 November 1986

FIELD BEHAVIOR OF NBC AGENTS (INCLUDING SMOKE AND INCENDIARIES)

Table of Contents

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DISPERSION CATEGORY	ATMOSPHERIC DESCRIPTION	TRADITIONAL ATMOSPHERIC CONDITIONS
1	Very Unstable	Lapse
2	Unstable	Lapse
3	Slightly Unstable	Neutral
4	Neutral	Neutral
5	Slightly Stable	Neutral
6	Stable	Inversion
7	Extremely Stable	Inversion

Figure 1-1. Atmospheric stability categories and conditions.

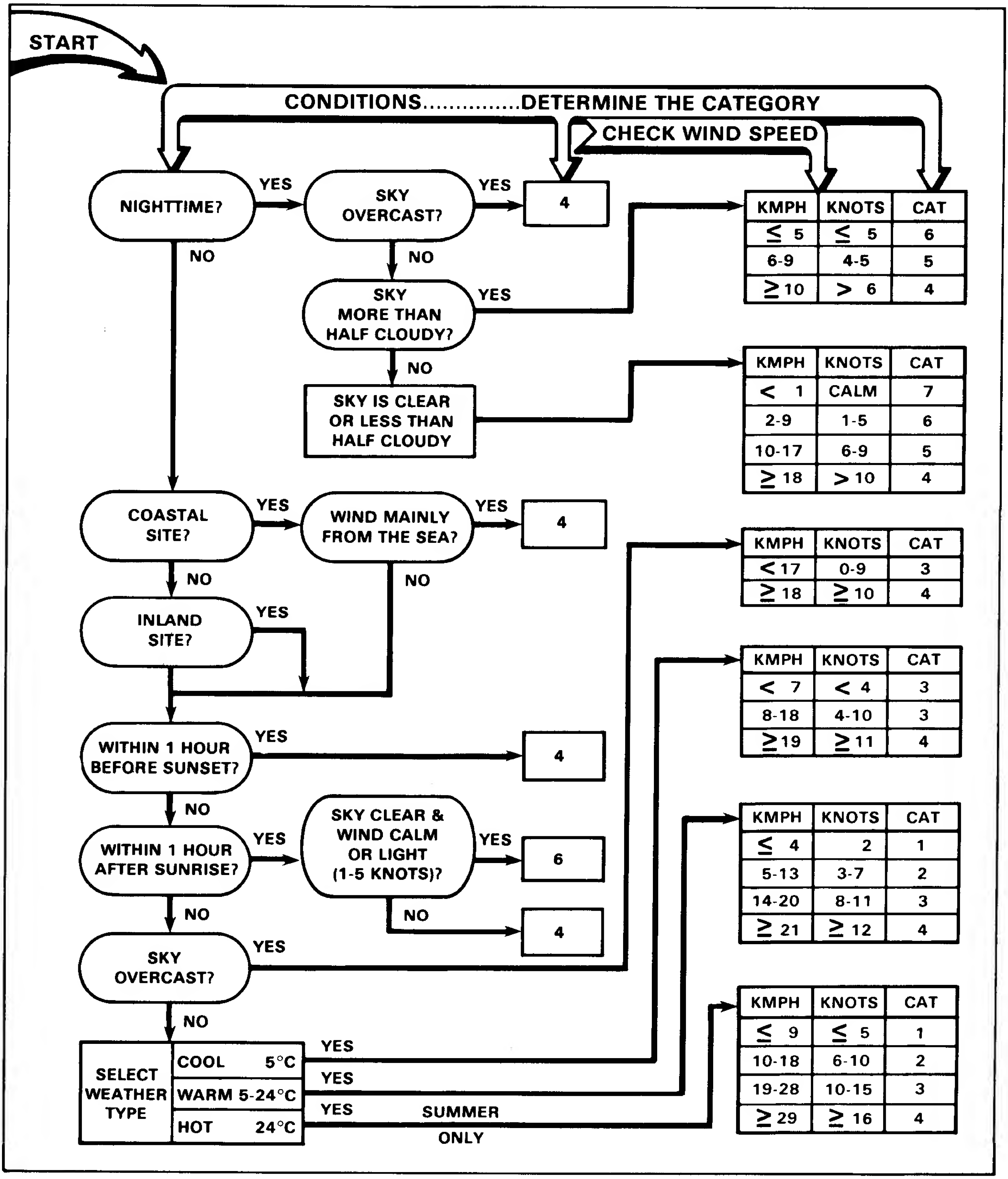


Figure 1-2. Stability decision tree.

Page 1-14 states that the mixed air layer height is 50-100 m on a clear, calm night, 400 m just before sunrise, and 2 km on a hot summer day

Table 1-3. Center line dosages at different distances downwind for different dispersion categories and wind speeds for a unit source. 100 kilograms of GB

STABILITY CATEGORY	Wind Speed	DOWNWIND DISTANCE IN KM							
		.5	1	2	4	6	10	20	30
		DOSAGES (mg-min/M³)							
1	1	57.82	10.960	2.4820	1.2070	.8048	.48290	.24140	.16100
	3	19.15	3.628	.8224	.3998	.2665	.15990	.07995	.05330
	5	11.47	2.174	.4928	.2396	.1597	.09582	.04791	.03194
2	3	65.93	16.480	4.121	1.0300	.4671	.22840	.11360	.07575
	6	32.86	8.215	2.054	.5135	.2328	.11380	.05663	.03775
	10	19.75	4.938	1.235	.3087	.1400	.06843	.03404	.02269
3	3	172.60	46.26	12.400	3.321	1.5370	.5825	.18010	.11510
	7	73.86	19.79	5.302	1.421	.6576	.2492	.07703	.04925
	12	43.09	11.55	3.094	.829	.3837	.1454	.04494	.02874
4	3	572.4	170.20	50.590	15.040	7.398	3.0260	.8997	.44450
	8	213.9	63.61	18.910	5.622	2.765	1.1310	.3363	.16620
	16	107.1	31.84	9.467	2.814	1.384	.5662	.1683	.08318
5	2	1,837.0	606.0	199.90	65.94	34.470	15.220	5.021	2.6250
	5	736.2	242.9	80.12	26.43	13.810	6.101	2.012	1.0520
	9	408.7	134.8	44.47	14.67	7.668	3.387	1.117	.5839
6	1	10,080.0	3,691.0	1,351.0	494.50	274.70	131.00	47.930	26.630
	3	3,339.0	1,222.0	447.4	163.80	90.96	43.37	15.870	8.818
	5	2,001.0	732.4	268.1	98.12	54.51	25.99	9.5120	5.284
7	HIGHER DOSAGES THAN ABOVE								

Table 1-4. Summary of favorable and unfavorable weather and terrain conditions for tactical employment of chemical agent vapor or aerosol. (The stability condition listed for the south slope is for the northern hemisphere; due to solar loading on the slope, the situation would be reversed for the southern hemisphere.)

FACTOR	UNFAVORABLE	MODERATELY FAVORABLE	FAVORABLE
Wind	Artillery employment if speed is more than 7 knots. Aerial bombs if speed is more than 10 knots.	Steady, 5 to 7 knots, or land breeze.	Steady, less than 5 knots, or sea breeze.
Dispersion Category	Unstable (lapse).	Neutral.	(Stable) inversion.
Temperature	Less than 4.4°C.	4.4° to 21.1°C.	More than 21.1°C.
Precipitation	Any.	Transitional.	None.
Cloud Cover	Broken, low clouds during daytime. Broken, middle clouds during daytime. Overcast or broken, high clouds during daytime. Scattered clouds of all types during daytime. Clouds of vertical development.	Thick, low overcast. Thick, middle overcast.	Broken, low clouds at night. Broken, middle clouds at night. Overcast or broken, high clouds at night. Scattered clouds of all types at night. Clear sky at night.
Terrain	Hilltops, mountain crests. South slopes* during daytime.	Gently rolling terrain. North slopes at night.	Even terrain or open water.
Vegetation*	Heavily wooded or jungle.	Medium dense.	Sparse or none.

*Cloud dissemination occurs above the canopy.

Chemical and biological contamination avoidance, FM 3-3 (1992)

10 grams/square meter

TABLE 1-2. Chemical Agent Persistency in Hours on CARC Painted Surfaces.

Temperature		GA/ GF[1]	GB[2,3]	GD[2,3]	HD[1]	VX[2,3]
C°	F°					
-30	-22	*	110.34	436.69	**	***
-20	-4	*	45.26	145.63	**	***
-10	14	*	20.09	54.11	**	***
0	32	*	9.44	22.07	**	***
10	50	1.42	4.70	9.78	12	1776
20	68	0.71	2.45	4.64	6.33	634
30	86	0.33	1.35	2.36	2.8	241
40	104	0.25	0.76	1.25	2	102
50	122	0.25	0.44	0.70	1	44
55	131	0.25	0.34	0.51	1	25

NOTE

1 For grassy terrain multiply the number in the chart by 0.4.
2 For grassy terrain multiply the number in the chart by 1.75.
3 For sandy terrain multiply the number in the chart by 4.5.
* Agent persistency time is less than 1 hour.
** Agent is in a frozen state and will not evaporate or decay.
*** Agent persistency time exceeds 2,000 hours.

REFERENCE BOOK
3—2*

U.S. ARMY COMMAND AND GENERAL STAFF COLLEGE
Fort Leavenworth, Kansas, *25 July 1983*

CHEMICAL WEAPONS EMPLOYMENT DATA

*This reference book replaces RB 3—2, 8 July 1981, for all resident and nonresident programs.

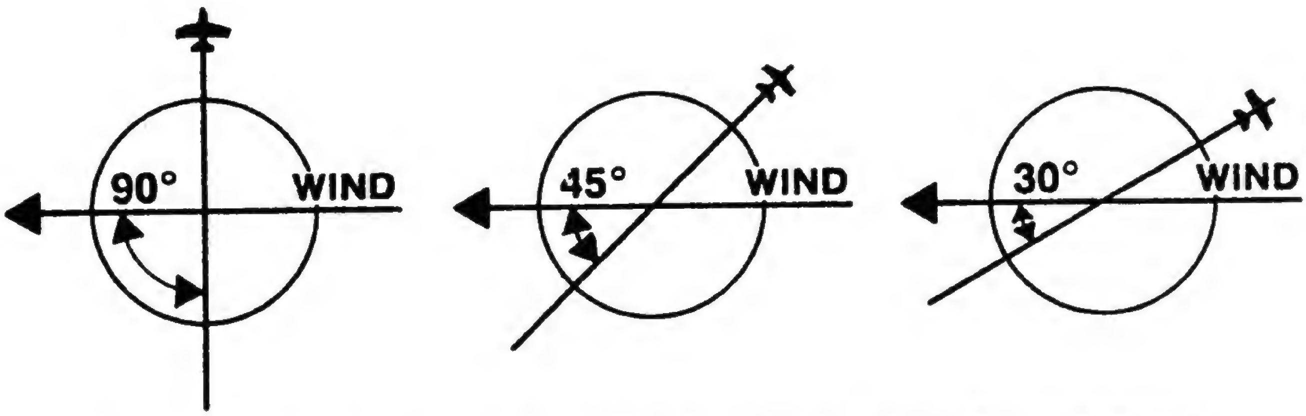
83-(RB 3-2)-3625

Section X
Spray Tank/VX

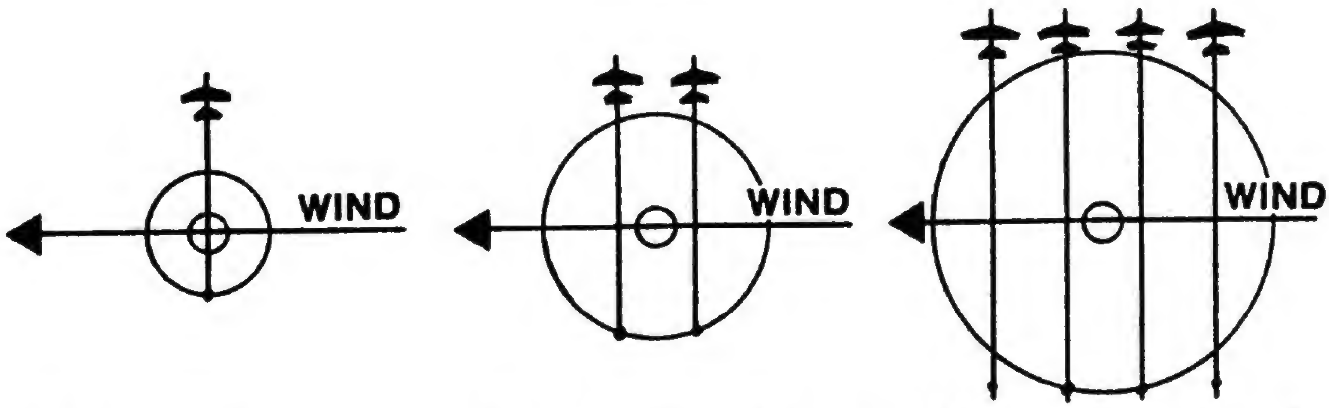
AIM POINT & FLIGHT PATH ADJUSTMENTS
VARIABLE DELIVERY TECHNIQUES

DELIVERY SYSTEM	TANKS/AIRCRAFT	AIRCRAFT SPEED*
Refer to Air Force & Navy Publications	Minimum 1 Maximum 2	450 Knots Centered Delivery

$$\textbf{Altitude of Spray Release Line} = \frac{\textbf{Windspeed - Height Product (VWH)}}{\textbf{Windspeed in Knots}}$$



FLIGHT PATH IN RELATION TO WIND DIRECTION



500-M TARGET RADIUS 1,000-M TARGET RADIUS 1,500-M TARGET RADIUS

Flight path Initiation point is leading edge of target Target center

**Used on all tables in this section.*

Table I-79. Spray Tank/VX Aim Point & Flight Path Adjustments

Spray Tank/VX

Expected Fraction of Casualties

PROTECTION CATEGORY: A (NO MASK OR PROTECTIVE CLOTHING)
CASUALTIES WITHIN: 1/2 HOUR

FLOW RATE	WIND ANGLE	TARGET RADIUS (Meters)	VWH 500 NO. AIRCRAFT 1	2	4	VWH 750 NO. AIRCRAFT 1	2	4	VWH 1000 NO. AIRCRAFT 1	2	4	VWH 2000 NO. AIRCRAFT 1	2	4	VWH 3000 NO. AIRCRAFT 1	2	4
ONE TANK AT HALF FLOW	90°	500	.08	.15	.20	.17	.37	.60	.25	.46	.68	.25	.43	.60	.19	.35	.50
		1000	.01	.04	.10	.06	.15	.31	.09	.19	.45	.09	.20	.45	.09	.20	.45
		1500	–	.02	.07	–	.06	.14	–	.06	.19	–	.06	.22	–	.08	.23
	45°	500	.04	.11	.23	.13	.29	.61	.20	.41	.69	.22	.41	.64	.21	.37	.57
		1000	.01	.04	.11	.04	.10	.23	.07	.16	.36	.08	.19	.42	.08	.19	.42
		1500	–	–	.07	–	.06	.12	–	.08	.18	–	.08	.20	–	.08	.22
	30°	500	.02	.07	.16	.10	.23	.48	.15	.32	.64	.17	.36	.62	.18	.35	.57
		1000	–	.03	.08	.03	.09	.20	.06	.13	.29	.07	.15	.34	.07	.16	.36
		1500	–	–	.04	–	.04	.09	–	.06	.14	–	.08	.18	–	.08	.20
TWO TANKS AT HALF FLOW	90°	500	.08	.17	.30	.22	.46	.69	.34	.55	.69	.31	.50	.65	.25	.43	.60
		1000	.01	.05	.11	.10	.19	.41	.13	.29	.61	.15	.33	.53	.18	.35	.51
		1500	.01	.03	.10	.05	.11	.25	.07	.17	.38	.09	.20	.46	.09	.22	.49
	45°	500	.06	.13	.28	.18	.37	.71	.27	.50	.71	.30	.50	.67	.29	.47	.62
		1000	.02	.06	.13	.06	.14	.31	.11	.24	.51	.13	.29	.60	.15	.32	.63
		1500	–	.02	.08	.03	.09	.20	.06	.14	.31	.07	.17	.38	.08	.19	.42
	30°	500	.04	.09	.39	.13	.29	.73	.20	.41	.69	.23	.44	.63	.24	.43	.57
		1000	.01	.04	.10	.05	.11	.26	.09	.19	.41	.10	.23	.51	.12	.26	.56
		1500	–	.01	.06	.02	.07	.14	.04	.11	.24	.06	.13	.29	.07	.15	.34

PROTECTION CATEGORY: A (NO MASK OR PROTECTIVE CLOTHING)
CASUALTIES WITHIN: 1 HOUR

FLOW RATE	WIND ANGLE	TARGET RADIUS (Meters)	VWH 500 NO. AIRCRAFT 1	2	4	VWH 750 NO. AIRCRAFT 1	2	4	VWH 1000 NO. AIRCRAFT 1	2	4	VWH 2000 NO. AIRCRAFT 1	2	4	VWH 3000 NO. AIRCRAFT 1	2	4
ONE TANK AT HALF FLOW	90°	500	.08	.20	.27	.25	.50	.70	.36	.57	.69	.33	.53	.64	.28	.48	.58
		1000	.02	.06	.15	.10	.22	.47	.16	.34	.65	.19	.39	.65	.22	.40	.63
		1500	–	.04	.09	–	.10	.23	–	.12	.34	–	.15	.41	–	.21	.42
	45°	500	.06	.14	.30	.19	.40	.71	.28	.52	.72	.31	.52	.68	.30	.49	.64
		1000	.02	.06	.14	.07	.15	.33	.11	.25	.52	.14	.29	.55	.16	.32	.54
		1500	–	.02	.07	–	.08	.19	–	.13	.34	–	.16	.38	–	.19	.43
	30°	500	.04	.10	.22	.14	.30	.63	.21	.43	.69	.24	.45	.65	.25	.45	.59
		1000	.01	.04	.10	.05	.12	.27	.09	.19	.41	.10	.23	.48	.12	25	.49
		1500	–	.01	.05	–	.06	.14	–	.11	.24	–	.14	.31	–	.16	.37
TWO TANKS AT HALF FLOW	90°	500	.11	.24	.41	.32	.57	.74	.39	.59	.72	.35	.55	.69	.29	.47	.66
		1000	.03	.08	.19	.13	.28	.58	.21	.43	.72	.27	.49	.71	.31	.51	68
		1500	.01	.05	.14	.07	.16	.37	.12	.26	.56	.16	.34	.66	.19	39	.67
	45°	500	.08	.17	.37	.23	.48	.75	.35	.57	.72	.35	.55	.68	.32	.51	.65
		1000	.03	.08	.17	.09	.20	.42	.16	.34	.67	.20	.42	.71	.24	.47	.71
		1500	.01	.03	.10	.05	.13	.28	.09	.20	.44	.12	.26	.55	.14	.30	60
	30°	500	.05	.13	.51	.17	.37	.74	.26	.50	.71	.28	.49	65	.28	.48	.64
		1000	.02	.05	.13	.07	.16	.34	.12	.26	.55	.16	.33	.67	.18	38	.69
		1500	–	.02	.07	.03	.10	.20	.07	.15	.35	.10	.19	.43	.10	23	.48

Table I-80. Spray Tank/VX Expected Fraction of Casualties

PROTECTION CATEGORY: A (NO MASK OR PROTECTIVE CLOTHING)
CASUALTIES WITHIN: ULTIMATE

FLOW RATE	WIND ANGLE	TARGET RADIUS (Meters)	WINDSPEED-HEIGHT PRODUCT (VWH) 500 NO. AIRCRAFT 1	500 2	500 4	750 NO. AIRCRAFT 1	750 2	750 4	1000 NO. AIRCRAFT 1	1000 2	1000 4	2000 NO. AIRCRAFT 1	2000 2	2000 4	3000 NO. AIRCRAFT 1	3000 2	3000 4
ONE TANK AT HALF FLOW	90°	500	.14	.31	.43	.39	.62	.74	.39	.59	.69	.35	.55	.65	.30	.50	.60
		1000	.05	.12	.26	.18	.38	.69	.30	.54	.73	.35	.56	.70	.36	.56	.68
		1500	–	.06	.15	–	.21	.42	–	.31	.56	–	.34	.59	–	.41	.59
	45°	500	.10	.23	.49	.30	.56	.75	.39	.60	.72	.36	.56	.68	.33	.53	.65
		1000	.04	.10	.22	.12	.26	.53	.19	.39	.63	.23	.43	.61	.26	.44	.59
		1500	–	.06	.12	–	.16	.33	–	.27	.54	–	.35	.62	–	.41	.65
	30°	500	.07	.16	.36	.22	.45	.74	.30	.54	.69	.31	.52	.65	.30	.50	.60
		1000	.03	.07	.16	.09	.20	.42	.14	.29	.55	.16	.34	.56	.18	.35	.55
		1500	–	.04	.09	–	.12	.25	–	.20	.45	–	.27	.55	–	.33	.59
TWO TANKS AT HALF FLOW	90°	500	.18	.38	.64	.43	.64	.75	.39	.59	.73	.35	.55	.70	.30	.50	.67
		1000	.06	.15	.30	.21	.45	.74	.35	.59	.73	.39	.60	.71	.39	.59	.69
		1500	.04	.09	.22	.13	.28	.60	.22	.46	.72	.30	.54	.74	.34	.56	.72
	45°	500	.13	.28	.58	.35	.60	.75	.40	.61	.72	.36	.56	.68	.34	.53	.65
		1000	.05	.11	.27	.16	.33	.66	.27	.52	.75	.33	.57	.73	.37	.59	.72
		1500	.03	.06	.16	.10	.21	.44	.16	.34	.65	.21	.42	.69	.24	.46	.68
	30°	500	.09	.20	.72	.26	.51	.74	.33	.56	.74	.32	.53	.70	.31	.50	.67
		1000	.04	.09	.20	.12	.26	.54	.20	.41	.73	.25	.49	.74	.29	.53	.73
		1500	.02	.04	.12	.07	.16	.32	.12	.25	.52	.15	.30	.60	.17	.34	.61

Table I-81. Spray Tank/VX Expected Fraction of Casualties

Section XI
HD Munitions

HD DOSAGE REQUIREMENTS

HD DOSAGES mg/minute/cubic meter			PERSONNEL PROTECTION CATEGORY	CASUALTY EFFECTS	DEGREE OF DISABILITY	ONSET TIME	DURATION
HOT[1]	WARM[2]	COOL[3]					
50	50	50	"A" no mask or protective clothing	No significant injury; maximum safe dosage	--	--	--
100	100	100		Eye damage of threshold military significance	PARTIAL	6-24 HR	1-3 DAYS
200	200	200		Temporary blindness	TOTAL	3-12 HR	2-7 DAYS
100	150	400	"B" or "C" with no protective clothing	No significant injury; maximum safe dosage	--	--	--
200	300	1,000		Skin burns of threshold military significance	PARTIAL	2-12 DAYS	1-2 WEEKS
500	1,000	2,000 to 4000		Severe genital burns	PARTIAL TO TOTAL	2-7 DAYS	1-4 WEEKS
750	2,000 to 4,000	4,000 to 10,000		Severe generalized burns	PARTIAL TO TOTAL	4-12 HRS About 24 HRS	3-4 WEEKS 1-2 WEEKS
			"D" mask with protective clothing	HD IS NOT RECOMMENDED FOR USE IN THIS PROTECTION CATEGORY.			

[1]Hot, humid; above 80° F; sweating skin
[2]Warm; 60°-80° F; skin not wet with sweat
[3]Cool; 40°-60° F; cool, dry skin

Table I-85. HD Munitions

HD Contamination Replenishment Time (Rate Factors)

TERRAIN FACTOR **X** WINDSPEED FACTOR **X** GROUND SURFACE TEMPERATURE FACTOR **X** TEMPERATURE GRADIENT FACTOR[2] (STABILITY) **=** TIME (HOURS) FOR 50% EVAPORATION OF HD

FACTORS

TERRAIN	WINDSPEED[1] (knots)	GROUND SURFACE TEMPERATURE (°F)	TEMPERATURE GRADIENT[2]
	1 = 3.1		
OPEN	2 = 1.8		INVERSION = 1.2
GRASSLAND = 1	3 = 1.3		
	4 = 1.0	50° = 4.0	
		60° = 2.5	
FOREST OR	5 = 0.8	70° = 1.6	NEUTRAL = 1.0
JUNGLE = 1	6 = 0.7	80° = 1.0	
	7 = 0.6	90° = 0.6	
	9 = 0.5	100° = 0.4	
	11 = 0.4	110° = 0.3	
		120° = 0.2	
BARREN SOIL	14 = 0.3		LAPSE = 0.7
OR SAND = 2	18 = 0.3		

[1]at 2 meters high in the open
[2]in the open

Table I-96. HD Contamination Replenishment Time (Rate Factors)

Approximate Duration of Hazard in Contaminated Terrain

TASK	TERRAIN	APPROXIMATE TIME AFTER CONTAMINATION THAT PRESCRIBED TASKS MAY BE PERFORMED WITH NEGLIGIBLE RISK[1] (Not wearing protective clothing)[2]			
		BLISTER AGENT (HD) TEMPERATURE[3]		NERVE AGENT (VX-GB) UNIFORM[4]	
		WARM (70°-85°F)	HOT (80°-100°F)	SUMMER	WINTER
		WEARING MASKS			
TRAVERSAL[5] (Walking across area 2 hours or less	Bare soil or low vegetation[6] (except sand)	36 HOURS	36 HOURS	5 HOURS	2 HOURS
	High vegetation, including jungle and heavy woods	4 DAYS	2 DAYS	28 HOURS	10 HOURS
		NOT WEARING MASKS[7]			
OCCUPATION (Without hitting ground 24 hours)	Bare soil or low vegetation[6] (except sand)	4 DAYS	3 DAYS	32 DAYS	13 DAYS
	High vegetation, including jungle and heavy woods	4 DAYS	3 DAYS	32 DAYS	13 DAYS
OCCUPATION (Involving advance under fire 24 hours)	Bare soil or low vegetation[6] (except sand)	4 DAYS	3 DAYS	32 DAYS	13 DAYS
	High vegetation including jungle and heavy woods	6 DAYS	4 DAYS	50 DAYS	18 DAYS

[1]These times are safe-sided for troop safety.
[2]Leather combat boots treated with protective dubbing or rubber combat boots are worn.
[3]Effects of blister agent vary significantly with temperature. Mustard freezes in temperatures below 60°F and can present a hazard when the temperature rises.
[4]Protection from V-agent and thickened G-agent varies significantly with layers of clothing worn.
[5]For personnel walking for 2 hours in an area contaminated by blister agents, the limiting factor is the vapor hazard. If only a few minutes are required for traversal of the area, the task can be initiated at earlier times than those given.
[6]Times shown are not applicable to sand, which will hold chemical agents for longer periods of time than those given.
[7]The data refer to approximate times at which personnel could occupy contaminated areas without having to wear protective masks for protection against vapor hazard.

Table I-97. Approximate Duration of Hazard in Contaminated Terrain

WARNING
This table is intended as a guide only.
Chemical agent detectors must be used to determine the extent of actual contamination and vapor hazards.

Table 5-2. Potential Biological Warfare Agents.

Microorganism	Mode of Transmission	Incubation Period (Days)[2]	Mortality Rate (Percent)2	Vaccine ([3])	Treatment ([4])
Bacteria					
Bacillus Anthracis (Anthrax)	A, D[9], I	1-7	5-1005	+	E[6]
Francisella Tularensis (Tularemia)	A, D[9], I, V	1-10	<30	+ +	E
Yersinia Pestis (Plague)	A, V	2-6	25-1007	+ + +	E[8]
Vibrio Cholerae (Cholera)	I	1-5	15-90	+ + +	E
Corynebacterium Diptheriae (Diptheria)	A, D[9]	2-5	5-12	+ + +	E
Salmonella Typhi (Typhoid Fever)	I	6-21	7-14	+ + +	E
Rickettsiae					
Rickettsia SPP (Spotted fevers group)	V	6-15	10-40	+ + +	E
Rickettsiae (Endemic or flea-borne typhus)	V	6-14	2-5	N	E
Rickettsia (Rocky Mountain spotted fever)	V	3-10	30 (approx)	N	E
Coxiella Burnetii (Q fever)	A, I	14-21	<1	+ +	E

1 Transmission can be by aerosol-A, direct contact-D, ingestion-I, and/or vector-V.
2 Incubation periods and mortality rates vary according to a number of factors (such as ability of the host to resist infection, infective dose, portal of entry, and virulence of the microorganism).
3 + indicates vaccine available but of questionable value; + + indicates vaccine available, but mainly used in high risk individuals; + + + indicates vaccine used extensively; N indicates no vaccine available.
4 E indicates effective treatment available; N indicates no specific treatment.
5 The mortality rate is lower when the agent enters through the skin; higher when it enters through the respiratory tract.
6 Treatment must be initiated in the earliest stage of the pulmonary form to be effective.
7 The 25 percent represents mortality due to bubonic form; 100 percent represents mortality due to pneumonic form.
8 Mosquitoes are thought to be the primary vectors, but this has not been proven.
9 Direct contact refers to being bitten by a rabid animal, which is the usual means of transmission, or coming into contact with a rabid animal.

Table 5-2. Potential Biological Warfare Agents (continued).

Microorganism	Mode of Transmission	Incubation Period (Days)[2]	Mortality Rate (Percent)2	Vaccine ([3])	Treatment ([4])
Viruses					
Eastern Equine Encephalitis (EEE)	V[8]	4-24	60 (Approx)	N	N
Venezuelan Equine Encephalitis (VEE)	V[8]	4-24	<1	+ +	N
Japanese B Encephalitis	V (Mosquito)	5-15	10-80	+ +	N
Russian SpringùSummer Encephalitis (RSSE)	V (Tick)	7-14	3-40	+	N
Yellow Fever	V (Mosquito)	3-6	5-40	+ + +	N
Dengue Fever	V (Mosquito)	4-10	<1	+	N
Pox Virus					
Variloa Virus (Smallpox)	A, D[9]	7-16	10-25	+ + +	N
Hantaan Virus (Hemorrhagic Fever with Renal Syndrome)	A, V				
Phlebovirus (Rift Valley Fever)	V (Mosquito)	4-6	<1	N	N
Nairovirus (Crimean-Congo Hemorrnagil Fever)	V (Tick)	3-7			
Bunyavirus (LA Crosse)	V (Mosquito)				
Phlebovirus(Sandfly)	V (Sand fly)	3-6			

1 Transmission can be by aerosol-A, direct contact-D, ingestion-I, and/or vector-V.

2 Incubation periods and mortality rates vary according to a number of factors (such as ability of the host to resist infection, infective dose, portal of entry, and virulence of the microorganism).

3 + indicates vaccine available but of questionable value; + + indicates vaccine available, but mainly used in high risk individuals; + + + indicates vaccine used extensively; N indicates no vaccine available.

4 E indicates effective treatment available; N indicates no specific treatment.

5 The mortality rate is lower when the agent enters through the skin; higher when it enters through the respiratory tract.

6 Treatment must be initiated in the earliest stage of the pulmonary form to be effective.

7 The 25 percent represents mortality due to bubonic form; 100 percent represents mortality due to pneumonic form.

8 Mosquitoes are thought to be the primary vectors, but this has not been proven.

9 Direct contact refers to being bitten by a rabid animal, which is the usual means of transmission, or coming into contact with a rabid animal.

Table 5-3. Threat Toxins.

Type of Toxin	Means of ID	Symptoms in Man	Effects on Man	Rate of Action	How Normally Disseminated	Protection Required	Decontamination
Mycotoxins	None	Vomiting, eye and skin irritation, dizziness, bloody diarrhea, and blisters.	Can incapacitate or kill, depending on concentration.	Rapid	Dusts, droplets, aerosols, smokes, or covert means	Protective mask and protective clothing	Soap and water, bleach, M258-series kit, STB and DS2
Enterotoxins	None	Severe vomiting and diarrhea, painful cramps, and weakness	Primarily incapacitates, assuming proper first aid is conducted	Same as above	Same as above	Same as above	Same as above
Botulinum Toxin	None	Double vision, weakness, difficulty in speech and swallowing, and respiratory paralysis	Kills	Delayed	Same as above	Same as above	Same as above

POTENTIAL MILITARY CHEMICAL/BIOLOGICAL AGENTS AND COMPOUNDS, US Army FM 3-11.9, 2005

Table G-4. Toxicity Estimates for CW Agents

ROE		Liquid (mg/70 kg man)		Inhalation/Ocular (mg-min/m^3)			Inhalation (mg/m^3)	Ocular (mg-min/m^3)		Percutaneous Vapor (mg-min/m^3)			
Endpoints		Lethal (LD_{50})	Severe (ED_{50})	Lethal (LCt_{50})	Severe (ECt_{50})	Mild (ECt_{50})	Odor Detection (EC_{50})	Severe (ECt_{50})	Mild (ECt_{50})	Lethal (LCt_{50})		Severe (ECt_{50})	
										Moderate	Hot	Moderate	Hot
Choking Agents	CG	-	-	1,500 (2-60)	-	-	6 S	-	-	-	-	-	-
	DP	-	-	1,500P (10-60)	-	-	4 S	-	-	-	-	-	-
Nerve Agents	GA	1,500	900	70 (2)	50 (2)	0.4 (2)	-	-	-	15,000 (30-360)	7,500P (30-360)	12,000 (30-360)	6,000P (30-360)
	GB	1,700	1,000	35 (2)	25 (2)	0.4 (2)	-	-	-	12,000 (30-360)	6,000P (30-360)	8,000 (30-360)	4,000P (30-360)
	GD	350	200	35 (2)	25 (2)	0.2 (2)	-	-	-	3,000 (30-360)	1,500P (30-360)	2,000 (30-360)	1,000P (30-360)
	GF	350	200	35 (2)	25 (2)	0.2 (2)	-	-	-	3,000 (30-360)	1,500P (30-360)	2,000 (30-360)	1,000P (30-360)
	VX	5	2	15 (2-360)	10 (2-360)	0.1 (2-360)	-	-	-	150 (30-360)	75P (30-360)	25 (30-360)	12P (30-360)
	Vx	NR											
Blood Agent	AC	-	-	2860P (2)	NR		34 S	-	-	-	-	-	-
	CK	-	-	NR	NR		12 S	-	-	-	-	-	-
	SA	-	-	7,500P (2)	-	-	-	-	-	-	-	-	-
Blister Agents	HD	1400	600	1,000 (2)	-	-	0.6 – 1 S	75 (2-360)	25 (2-360)	10,000 (30-360)	5,000P (30-360)	500 (30-360)	200 (30-360)
	HN-1	1400P	600P	1,000P (2)	-	-	-	75P (2)	25P (2)	10,000P (30)	5,000P (30)	500P (30)	200P (30)
	HN-2	1400P	600P	1,000P (2)	-	-	-	75P (2)	25P (2)	10,000P (30)	5,000P (30)	500P (30-360)	200P (30-360)
	HN-3	1400P	600P	1,000P (2-360)	-	-	-	75P (2-360)	25P (2-360)	10,000P (30-360)	5,000P (30-360)	500P (30-360)	200P (30-360)
	HT	1400P	600P	1,000P (2-360)	-	-	-	75P (2-360)	25P (2-360)	10,000P (30-360)	5,000P (30-360)	500P (30-360)	200P (30-360)
	L	1400P	600P	1,000P (2-360)	-	-	8 S	75P (2-360)	25P (2-360)	5,000 - 10,000P (30-360)	2,500 - 5,000P (30-360)	500P (30-360)	200P (30-360)
	HL	1400P	600P	1,000P (2-360)	-	-	2 S	75P (2-360)	25P (2-360)	10,000P (30-360)	5,000P (30-360)	500P (30-360)	200P (30-360)

It may be several weeks or even months before I shall ask you to drench Germany with poison gas, and if we do it, let us do it one hundred per cent. In the meanwhile, I want the matter to be studied in cold blood by sensible people and not by that particular set of psalm-singing uninformed defeatists which one runs across now here, now there (Churchill 1944).

Gilbert M (1991). *Churchill. A Life*, pp. 782–783. London: Heinemann.

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USAWC RESEARCH ELEMENT
(Research Paper)

What's Wrong With Gas Warfare?

by

Lt Col Stanley D. Fair
Chemical Corps

US Army War College
Carlisle Barracks, Pennsylvania
8 April 1966

PUBLIC INFORMATION PROGRAM

A new national policy on gas warfare such as the one presented above can provide the necessary guidance for the people as to the importance of gas weapons and their role. The formulation of policy must precede or accompany any attempt to educate the public on gas warfare since "public knowledge of facts is not understanding until it can be set in the framework of policy and goals."[11]

Public resistance to a new policy may occur because of false impressions about gas warfare. Since the American people have considerable influence on adoption of policy, they must be provided objective information on gas warfare. As "Elihu Root...wrote... when policy on foreign affairs is largely dominated by the people, the danger lies in mistaken beliefs and emotions."[12]

The issue of gas warfare is emotional and political. In this respect it is similar to many issues facing our government today; communism and race relations are examples. Government officials have led the way with free and open discussions on these controversial subjects and should do the same with gas warfare. This leadership is essential, as Major General W.M. Creasy warned a House Science Committee in 1959:

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[11]"Public Understanding--The Ultimate Weapon?" The General Electric Defense Quarterly, Vol. 3, Oct.-Dec. 1960, p. 33.

[12]William Albig, Modern Public Opinion, p. 12.

Albig, William. Modern Public Opinion. New York: McGraw-Hill, 1956. (HM261 A451)

> I do not believe the American people are going to read any information on a subject when the American government says this is too horrible to use and we are not going to use it.[13]

The first step in a public information program is to go after the roots of public hostility towards gas warfare: World War I propaganda. The effects of the Allied propaganda did not evaporate with the gas clouds of World War I "for that half-century-old vision of the blue-faced men at Ypres choking to death, has left an indelible impression upon the mind of the world."[14] As late as 1953 the horrors of the first gas attack were brought out in the memoirs of a war correspondent who served with the Red Cross at Ypres:

> This horror was too monstrous to believe at first... the savagery of it, of the sight of men choking to death with yellow froth, lying on the floor and out in the fields, made me rage with an anger which no later cruelty of man...ever quite rekindled; for then we still thought all men were human.[15]

The tragedy of the first gas attack should be admitted in any program of public information: the soldiers were helpless; those who did not panic and run suffered a slow and painful death. On the other hand, it should be pointed out that protection against chlorine was simple and was achieved before the second gas attack took place two days later. Ypres was an isolated incident.

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[13]Quoted in US Congress, House, Committee on Science and Astronautics, Chemical, Biological and Radiological Warfare Agents, p. 22.

[14]Hanson W. Baldwin, "After Fifty Years the Cry of Ypres Still Echoes--'GAS!'," New York Times Magazine, 18 Apr. 1965, p. 50.

[15]Geoffrey W. Young, The Grace of Forgetting, p. 233.

The best counter to propaganda is to tell the truth. In getting the facts to the public it is important to differentiate between information which can and cannot be made available to the public. They should know in general what is going on, but the details must remain classified to protect national security. It is important also to differentiate between information which should and should not be made available to the public. Articles on gas warfare should pass the test of one criterion before release by the Department of Defense: does it contribute to public understanding of gas warfare, or does it add to the misconceptions of mystery and indecency?

The free and open discussion on nuclear warfare has resulted in the willingness of the responsible American to accept the nuclear weapon as an unpleasant fact, essential to his country's safety. The current secrecy surrounding gas warfare can create a lack of confidence in the capabilities of gas. Captain Liddell Hart told of British tanks developed during World War II that were fitted with special searchlights for blinding the enemy as well as for night firing. This invention was "kept so secret that the commanders in the field regarded them distrustfully and thus repeatedly hesitated to employ such unfamiliar instruments."[19]

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[19] B.H. Liddell Hart, Deterrent of Defense, pp. 86-87.

CIVIL DEFENCE

why we need it

Message from the Home Secretary and the Secretary of State for Scotland

For over 30 years our country, with our allies, has sought to avoid war by deterring potential aggressors. Some disagree as to the means we should use. But whatever view we take, we should surely all recognise the need – and indeed the duty – to protect our civil population if an attack were to be made upon us; and therefore to prepare accordingly.

The Government is determined that United Kingdom civil defence shall go ahead. The function of civil defence is not to encourage war, or to put an acceptable face on it. It is to adapt ourselves to the reality that we at present must live with, and to prepare ourselves so that we could alleviate the suffering which war would cause if it came.

Even the strongest supporter of unilateral disarmament can consistently give equal support to civil defence, since its purpose and effect are essentially humane.

George Younger

Why bother with civil defence?

Why bother with wearing a seat belt in a car? Because a seat belt is reckoned to lessen the chance of serious injury in a crash. The same applies to civil defence in peacetime.

War would be horrific. Everyone knows the kind of devastation and suffering it could cause. But while war is a possibility – however slight – it is right to take measures to help the victims of an attack, whether nuclear or 'conventional'.

But isn't it a waste of money in these days of nuclear weapons and the dreadful prospects of destruction?

No. It is money well spent if it shows people how they can safeguard themselves and their families.

But surely there is no real protection against a nuclear attack?

Millions of lives could be saved, by safeguards against radiation especially. But civil defence is not just protection against a nuclear attack. It is protection against *any* sort of attack. NATO experts reckon that any war involving the UK is likely at least to start with non-nuclear weapons. Indeed, while no war is likely so long as we maintain a credible deterrent, the likelihood of a nuclear war is less than that of a 'conventional' one.

But doesn't civil defence get people more war-minded, thus increasing the risk of conflict?

That is like saying people who wear seat belts are expecting to have more crashes than those who do not. Taking civil defence seriously means seeking to save lives in the catastrophe of an attack on our country.

To Sum Up

The case for civil defence stands regardless of whether a nuclear deterrent is necessary or not. Radioactive fallout is no respecter of neutrality. Even if the UK were not itself at war, we would be as powerless to prevent fallout from a nuclear explosion crossing the sea as was King Canute to stop the tide. This is why countries with a long tradition of neutrality (such as Switzerland and Sweden) are foremost in their civil defence precautions.

Civil defence is common sense

Further information:

Nuclear Weapons
ISBN 0 11 34055 X HMSO £3.50 (net)

Protect and Survive
ISBN 0 11 3407289 HMSO 50p (net)

Domestic Nuclear Shelters
ISBN 0 11 3407378 HMSO 50p (net)

Domestic Nuclear Shelters – Technical Guidance
ISBN 0 11 34073786 HMSO £5.50 (net)

CIVIL PREPAREDNESS AND LIMITED NUCLEAR WAR

HEARINGS

BEFORE THE

JOINT COMMITTEE ON DEFENSE PRODUCTION CONGRESS OF THE UNITED STATES

NINETY-FOURTH CONGRESS

SECOND SESSION

APRIL 28, 1976

Printed for the use of the
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HEARING ON CIVIL PREPAREDNESS AND LIMITED NUCLEAR WAR

WEDNESDAY APRIL 28, 1976

U.S. SENATE AND
U.S. HOUSE OF REPRESENTATIVES,
JOINT COMMITTEE ON DEFENSE PRODUCTION,
Washington, D.C.

The committee met at 10:05 a.m. in room 5302, Dirksen Senate Office Building, Hon. William Proxmire, vice chairman of the subcommittee, presiding.

Present: Senators William Proxmire and John Sparkman.

Senator PROXMIRE. The committee will come to order.

Today's hearing inaugurates a review by the Joint Committee on our Nation's civil preparedness. It is the first such congressional review in over two decades.

By civil preparedness, we mean those mainly civilian measures by which we seek to protect the lives and property of our citizens.

This is the first function of any government. A government which cannot meet this fundamental test of defending its people and the national treasure is not likely to survive for very long.

In subsequent hearings, the committee will examine the adequacy of Federal, State, and local preparedness programs, including plans for fallout shelters, strategic evacuation, preparedness exercises and drills, civil defense stockpiles, and continuity of government. Likewise, the Joint Committee will inquire into the organization of the Government for preparedness. It will also review the Nation's industrial and economic preparedness in terms of the defense industrial base.

This is an especially timely undertaking. Over the past 2 years the United States has been moving from a declared nuclear policy of mutual assured destruction to one of flexible response, or limited nuclear war.

In the minds of some eminent strategists, this implies a lowering of the nuclear weapons threshold, a quickening of the trigger finger on the missile launch console, and an increased probability of uncontrolled nuclear conflict.

But to other equally qualified experts, this shift in strategic doctrine, this shift to larger numbers of more flexible, or more versatile and accurate weapons and control systems does not undermine deterrence of nuclear war; instead, it enhances deterrence.

Well, it can't be both ways and whenever you have such a complete divergence in expert opinion, it is time for a careful review of the facts.

These hearings are also timely in that there are increasing rumors of a civil defense gap, with the Soviet Union well in the lead.

In this year's annual report, Defense Secretary Rumsfeld stated that, and I quote:

> An asymmetry has developed over the years that bears directly on our strategic relationship with the Soviets and on the credibility of our deterrent posture. For a number of years, the Soviets have devoted considerable resources to their civil defense effort which emphasizes the extensive evacuation of urban populations prior to the outbreak of hostilities, the construction of shelters in outlying areas, and compulsory training in civil defense for well over half the Soviet population. The importance the Soviets attach to this program at present is indicated not only by the resources they have been willing to incur in its support, but also by the appointment of a deputy minister of defense to head this effort.

Now, the term "asymmetry" used by the Secretary sounds to a non-expert like me like a four-bit word for "gap." We have heard a great deal over the years about gaps that never materialized or proved unimportant. Yet we have spent a lot of money to eliminate the non-existent or the insignificant. It is for this reason that the committee last week published the declassified text of the 1957 Gaither Report which invented the first missile gap.

STATEMENT OF HON. PAUL NITZE, FORMER SECRETARY OF THE NAVY, DEPUTY SECRETARY OF DEFENSE, AND MEMBER OF THE SALT DELEGATION

Mr. Nitze. Mr. Chairman, my interest in the questions which this committee is discussing began in 1944 when I was asked to be a director of the U.S. Strategic Bombing Survey. The required qualification of the directors was that they have no prior knowledge of military strategy or of air power, and could thus be presumed to be unbiased in appraising the effects of the immense U.S. strategic air effort in World War II. I spent the next 2 years in Europe and then in the Pacific in intensive work, in association with what I believe to have been the best talent available to this country, to try to understand something about both subjects. In the Pacific portion of the survey, as Vice Chairman, I was in effective command of the operation, including the detailed study of the effects of the weapons used at Hiroshima and Nagasaki.

Since that time much has changed. Weapons have increased in yield and missiles now have an intercontinental range. But these changes are hardly as revolutionary as the changes brought about by the role of effective air power in World War II and of the introduction of nuclear weapons in its closing phase. After all, the largest number of our nuclear reentry vehicles today are Poseidon warheads, each of which has an equivalent megatonnage less than twice that of the weapons used at Hiroshima and Nagasaki.

At Hiroshima and Nagasaki there was no air-raid warning and very few people availed themselves of the crude civil defense facilities which were available. Most of those that did, even at ground zero, in other words, directly under the explosion, which was at the optimum height of burst, survived. The trains were operating through Hiroshima 2 days after the explosion.

Let me paraphrase from an interchange I had in 1960 with Colonel Lincoln, head of the faculty at West Point, on this subject:

The Russians are careful students of Clausewitz. I do not believe they would ever ignore either the danger that a war once started might escalate to the full violence which the pure theory of war might indicate; on the other hand, they would never forget that war is a tool of policy and that every effort must be made to avoid letting it so escalate.[1]

[1] In this connection the following quotation from *Communist of the Armed Forces* in November 1975 is pertinent: "The premise of Marxism-Leninism on war as a continuation of policy by military means remains true in an atmosphere of fundamental changes in military matters. The attempt of certain bourgeois ideologists to prove that nuclear missile weapons leave war outside the framework of policy and that nuclear war moves beyond the control of policy, ceases to be an instrument of policy and does not constitute its continuation is theoretically incorrect and politically reactionary."

On the other hand, I can well imagine that they might consider a controlled nuclear conflict in which significant military targets, but not urban-industrial targets, are the initial objects of attack, if they thought war unavoidable.

In conclusion, I would like to comment on this committee's print containing the Gaither Report of 1957.

I have now read that report for the first time in nearly 20 years. I am impressed—especially in light of the information then available to the Gaither committee—by the care and comprehensiveness of that committee's examination of the problems assigned to it for study. I note in contrast the cavalier imprecision reflected in the foreword prepared by this committee's staff.

It is not true that the Gaither Report ignored arms control, nor is it true that the report spoke of U.S. strategic inferiority as then a fact. To the contrary, the Gaither Report described the United States as then "capable of making a decisive attack on the U.S.S.R." In view of SAC's vulnerability "to a surprise attack in a period of lessened world tension," the Gaither Report also noted the U.S.S.R.'s capability to make "a very destructive attack on this country."

The report then observed, "As soon as SAC acquires an effective 'alert' status, the United States will be able to carry out a decisive attack even if surprised," and it anticipated that juncture "as the best time to negotiate from strength, since the U.S. military position vis-a-vis Russia might never be so strong again."

In attempting to disparage the Gaither committee's analysis, the staff foreword cites a subsequent estimate "* * * that at the time of the Gaither Report the Soviet Union probably had fewer than a dozen operational ICBMs." In fact, at the time of the Gaither Report—only a few weeks after the sputnik launching—the Soviet Union obviously had no operational ICBMs. The Gaither Report made no assumption to the contrary. Indeed, it postulated 1959 as the probable year the Soviet Union would first have operational ICBMs; in fact, they first became operational in 1960. What was crucial at the time was not only the question of how many ICBMs would be operational when, but even more importantly the question of the speed with which the U.S. Air Force could achieve adequate early warning facilities and an appropriate alert posture.

The Gaither Report focused attention on those questions.

Summary Statement by the Honorable Paul H. Nitze

Mr. Chairman: My interest in the questions which this Committee is discussing began in 1944 when I was asked to be a director of the U.S. Strategic Bombing Survey. The required qualification of the directors was that they have no prior knowledge of military strategy or of air power, and could thus be presumed to be unbiased in appraising the effects of the immense U.S. strategic air effort in World War II. I spent the next two years in Europe and then in the Pacific in intensive work, in association with what I believe to have been the best talent available to this country, to try to understand something about both subjects. In the Pacific portion of the Survey, as Vice Chairman I was in effective command of the operation, including the detailed study of the effects of the weapons used at Hiroshima and Nagasaki.

Since that time much has changed. Weapons have increased in yield and missiles now have an intercontinental range. But these changes are hardly as revolutionary as the changes brought about by the role of effective air power in World War II and of the introduction of nuclear weapons in its closing phase. After all, the largest number of our nuclear reentry vehicles today are Poseidon warheads, each of which has an equivalent megatonnage less than twice that of the weapons used at Hiroshima and Nagasaki.

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I believe they will always pay close attention to the interrelationship of the offense and the defense and not ignore either side of the equation. I cannot believe they would so ignore the military core of war as to consider the type of controlled nuclear conflict discussed in some of the papers circulated by the Committee's staff where military targets are avoided and industrial targets are hit. On the other hand, I can well imagine that they might consider a controlled nuclear conflict in which significant military targets, but not urban-industrial targets, are the initial objects of attack, if they thought war unavoidable.

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made no assumption to the contrary. Indeed, it postulated 1959 as the probable year the Soviet Union would first have operational ICBMs; in fact, they first became operational in 1960. What was crucial at the time was not only the question of how many ICBMs would be operational when, but even more importantly the question of the speed with which the Air Force could achieve adequate early warning facilities and an appropriate alert posture.

The Gaither Report focused attention on those questions. Thereby the Report became a factor in stimulating an enormous effort on the part of the U.S. to move ahead with pertinent strategic programs. In those years the rate of expenditure on strategic programs was, allowing for inflation, about two and a half times the present rate. For all the great expense, the program was a bargain when considered against the calamitous potential consequences of permitting the strategic relationship to become unstable to the detriment of U.S. security and with increased risk to the maintenance of peace.

The Report placed first priority on the military measures necessary to maintain strategic stability and high quality deterrence. It placed a lower priority on those measures necessary to ensure survivability of the population in event deterrence were to fail. The two classes of measures are, however, interrelated.

STATEMENT OF HERMAN KAHN, DIRECTOR, HUDSON INSTITUTE

Senator PROXMIRE. Mr. Kahn.

Mr. KAHN. It is customary to start one's testimony with a statement of qualifications. Let me instead start with a disqualification.

I haven't really been spending very much time in the military field since 1965, but I started to go back last year, and I am now in the middle of reacquainting myself with the issues.

I might say though that comparing today's discussion to the sixties, there has been very little substantial improvement. In fact there have been some retrogressions. This both disturbs and surprises me.

Let me start by agreeing with Paul on two issues. The chairman just stated we can't have both increased and decreased deterrence. I believe that there are many measures which can go in both directions.

There are many measures which increase deterrence in one scenario or context, and decrease deterrence in another scenario or context. In particular, if one focuses on this abstract war, what Paul referred to as a pure military war, or a surprise attack out of the blue directed against civilians, then it is terribly easy to do many things which will decrease that deterrence.

But since I tend to feel we have, relatively speaking, too much deterrence of this situation I do not object to decreasing the deterrence of surprise attack out of the blue in favor of increasing deterrence in other situations. In fact there has been much too much attention to this simple situation. I know back in 1960, a number of polls were taken by Tom Schelling, by Weapon Systems Evaluation Group (WSEG) and others. In these polls analysts were asked "If a war occurred, what scenario do you think would have preceded the war?"

Almost universally, they agreed there would have been a very tense situation, say bombs bursting in Europe, and then either an attack by the Soviets because they got into serious trouble, an accidental war, or an attack by the U.S. All the analysts agreed that a surprise attack out of the blue, directed at cities, was far and away the least probable way that a war was likely to start.

And yet they all also agreed that 90 percent of their personal studies and effort went to that case and the other 10 percent or so went into a study of a surprise attack out of the blue which hit military bases. In other words, the analysts agreed, that even though they were able

to choose their own subjects of study, they were spending almost all of their time on scenarios which, in their judgment, were not probable or important. They simply were the easiest things to study and talk about.

[Additional remarks:]

Many analysts are still doing this, but do not seem to know that this emphasis distorts the realistic priorities.

Now, when we looked at civil defense in 1960—or today—it was really almost impossible to protect the population against a surprise attack directed against them. We found that it was also impossible to protect an economic base for massive war production against a surprise attack directed against the economic base.

Therefore, we did not ask ourselves, as a high priority, what does civil defense do for these objectives in these scenarios.

However we did not stop there. We went on to ask ourselves if there were any other roles for civil defense.

It seemed to us that there were a large number of roles. All of them tended to be second or third priority but still terribly important. When people said, "But that doesn't do any good in the first priority situation," we answered, "We don't care."

The first, perhaps the most important role, is to protect people when they are not targets. I am prepared to believe that doing this decreases deterrence, but I am willing to do it anyway.

I know when I examine the problem of attacking the Soviet Union that I want to preserve Moscow and Leningrad, my two biggest assets, and anything they do to make Moscow and Leningrad safe from becoming bonus targets improves my ability to plan war against the Soviets. Moscow and Leningrad are important to the Soviets and they are probably willing to do that. Deterrence is not the sole objective of policy.

In a book called *On Thermonuclear War* which I published in 1960, we mentioned what we called the Doomsday Machine was the highest possible deterrent, yet nobody wanted it. I might also mention that I made clear, in that book, that we didn't think there was any missile gap. In fact, just to go back over a little history of that, most people's recollection of the debate of that period tends to be wrong.

It is not true that the Democrats raised the issue of a missile gap against the Republican administration. That was a Republican statement. The Republicans predicted the Russians would have 300 missiles by 1960. But at the same time, the Republican administration said this wouldn't make any difference, because we had 2,000 bombers and they were more important than 300 missiles.

The great contribution of the Gaither Report, as Paul just said, was to make clear that if the Soviets had 300 missiles and we did not have any kind of warning system, then we might not have 2,000 bombers, because they could be destroyed by a surprise attack while still on the ground.

I also made clear, that while the Soviets probably would not have 300 operational missiles in 1960, if they did have them, we would be in trouble—that is, despite the predictions by the Republican administration we did not think they had such a force—but we were not sure.

What does one do when the other side may be able to do something in the near future and if one waits until he is certain before reacting, it is too late, while if one reacts early it may turn out to have been unnecessary?

Let me also make a remark about a release I saw from this committee which listed a series of predicted gaps which did not occur. In at least half the cases, people were rather clear that the gap might not occur, but they were not sure.

[Additional remarks:]

But they felt they had to worry about it ahead of time and even make some preparations because they could not afford to wait until all the facts were in.

Let me ask a question: What do you do if the other side exhibits a weapon system and has the production capability? You are not quite sure what he is going to do. Do you wait until he does it or do you worry about it?

In general this is a very complicated issue. In some cases, we almost have to make preparations ahead of time, even though they may be wasted. In other cases, we should wait until we are more sure; in still other cases, one just hopes for luck. But one should not, in my judgment, downgrade responsible officials who get concerned under such circumstances.

I might also draw attention to some studies done by Albert Wohlstetter. It is pointed out in these studies that in most cases, we have underestimated rather than overestimated U.S.S.R. future capability. I will ask that this report be sent to the committee.

If you look at the record, there has been more a problem of underestimation than overestimation. This is true in terms of the number of missiles the Soviets have had over time and in terms of Soviet capability on all kinds of other issues. We tend to remember the discussion when some hysterical people overstate the problem; then it turns out to be wrong. I would argue this is not at all the characteristic problem.

Let me turn to the major point I wanted to make today. I would argue that the scenario I worry about as the most probable scenario, is also the scenario which is least discussed. This is the case where there is opportunity for significant or even all-out mobilization before major thermonuclear attacks against the cities occur.

There are two recent and useful historical examples which illustrate this concept, the Korean War and World War II.

In June 1950, Congress was debating whether the budget should be $15, $16 or $17 billion. The previous year it had been $13 billion. A number of distinguished witnesses testified that $18 billion would strain the economy, but $16 billion was all right. North Korea marched on South Korea, and within 1 year, Congress authorized $60 billion, an increase by a factor of 4.

This was totally unexpected and totally changed the strategic problem. One should note that it would not have been possible to fit into even an $18 billion budget hardly any of the weapons systems we have procured since World War II. One could not have bought a Sage system, a B–47 system, a B–52 system, a Nike Hercules system, a Polaris system, and so on. None of these systems would have been feasible at the $5 or $6 billion budgets per service which were, roughly, current at that time.

As a result of this authorization, the Air Force budget was increased by about a factor of 5. The other two services had an increase of about 3. As a result, a whole new range of possibilities opened up for the services.

I can easily envisage a scenario for crisis in the future which involves military budgets of $500 billion or more. That would change, if you will, the whole character of strategic planning. I do not expect any such situations to arise with high probability, but I do not consider it paranoia or unwise to prepare for such situations.

Probably an even better prototype for the situation we are thinking about is pre-World War II. After World War I, much of the world became sick of war, and war became "unthinkable" to most people, particularly in the victorious "Allied Powers." Strategists and publicists talked about poison gas and knock-out blows; they thought all the capital cities would be destroyed by poison gas in the first few days of a war. They did not understand the idea of limitations in warfare—of mutual deterrence even after hostilities have broken out.

When Hitler got elected in 1933, people became interested in larger defense budgets. Then he marched into the Rhineland and, of course, defense budgets increased slightly. Then there was the Anschlus and then Munich, and more substantial increases in military budgets. With the invasion of Czechoslovakia, everybody got deeply concerned. Then, finally, there was the invasion of Poland, the formal declaration of war and then 7 months of more or less "phony war." As a result there was opportunity on both sides for 7 months' of full-time war production, before the war really opened up.

We would argue that similar possibilities should be considered today. Nobody is interested in jumping into a nuclear war today. Nobody is going to want to execute the usual picture of nuclear war, in which each side presses every button and goes home. It is extraordinarily difficult to believe such a scenario.

It might happen. But I would be willing to bet, if this were a betting matter, 50 to 1 against it.

On the other hand, the situation might arise in which there was a declaration of war, followed by a phony war, or a serious confrontation in which there were credible threats of war. By the way, in such a confrontation, the following dialog tends to occur.

Both sides are saying to the other side, "There is absolutely nothing at risk which justifies this terrible danger to which we are subjecting each other and the rest of the world. It is clear that whatever we are arguing about is simply not worth the risk of a thermonuclear war. Therefore, one of us has to be reasonable—and it isn't going to be me."

That is, by the way, a terribly persuasive argument.

At this point, each side is trying to explain why the other side should be reasonable. You don't have to have a great defense to do that. All you have to be able to do is say, "I believe my defense establishment is better than yours, in important ways."

I can imagine the Russians telling us. "You are telling us the money we spent on our defense establishment does us no good, but we spent it because we thought it does do good. We believe that this defense establishment of ours works. You don't, but we believe it does."

If you can get that point across, you are going to put great pressure on the other side to back down.

Senator PROXMIRE. Very strong chance of what? I missed that.

Mr. KAHN. If we believe that they believe they have confidence in their establishment, we are going to back down, whether or not their

confidence is justified, because we would be destroyed almost as much as a result of their mistaken belief as by a correct one. If the other man can give you a credible picture, that he believes he has a serious edge over you, then even if he does not objectively have that edge, you may be in trouble.

That is even more true for allies. If they think the other side believes it has an edge, the allies are going to hedge. Finally it is even more true for neutrals that in a bargaining situation the strategic balance is very complex (which should be an obvious point) and the outsider is likely to be excessively influenced by appearances. Who strikes first and how many are dead in each city are almost irrelevant to many of these issues.

Finally, a last point. When we write scenarios for nuclear war, we find it difficult to write a credible scenario which doesn't involve months or weeks of warning. I would guess we are as good at writing scenarios as anybody in the world. We have certainly written as many.

I want to warn the committee, on the other hand, that when we looked at World War I, we didn't find that scenario plausible. The mere fact we can't write a plausible scenario for a war doesn't mean it can't occur, because one can find historical examples to the contrary.

Nevertheless, every scenario we write for nuclear war involves days, weeks or months of tension. Evacuation, last moment mobilizations are extraordinarily possible. By the way, evacuations occur not as a result of secret intelligence or in any attempt to try to outrun the missiles or the bombers. The *New York Times* and the *Washington Post* provide the warning perhaps days before the attack. People or governments then get frightened and decide to decrease their vulnerability to attack. The idea is, can you exploit such warning if it is printed in the papers?

[Complete statement follows:]

Summary Paper and Briefing Notes on the Potential of the Defense Mobilization Base Concept by Herman Kahn, William Brown, and William Schneider, Jr.

This submission is the responsibility of the authors and is not to be construed as representing any official opinions of the Hudson Institute or any other associated individuals or agencies.

PREFATORY NOTE

The following paper represents a summary of studies developed by the staff and consultants of the Hudson Institute more or less continuously over the last fifteen years although naturally it focuses more intensively upon recent work—in particular, a summary of a report on the concept of mobilization warfare by Herman Kahn and William Schneider, Jr. Most of Hudson's program of civil defense and mobilization base studies has been accomplished under the direction of William Brown, Herman Kahn and William Schneider, Jr. and at least half the Institute's personnel have participated in one or more of them. This particular submission was prepared as a joint paper by the three people named above.

MOBILIZATION WARFARE

1. The concept of mobilization warfare

The notion of mobilization in a nuclear age has the appearance of a contradiction in terms when arrayed against the conventional concept of mobilization. Mobilization has in general, been associated with the redirection of national resources, both human and material away from traditional civilian pursuits to support a defense effort. To some extent, it has been possible to conceive of a limited mobilization of military forces and associated national resources to support

limited political objectives although the more traditional perception has been associated with a general mobilization of the entire industrial might and armed forces of a nation.

The possibility of intercontinental strategic nuclear attack made possible through the development of ICBM's, missile firing submarines, and long-range bombers have made the initiation and conclusion of a nuclear conflict appear to be a matter of hours or days, and certainly not more than a few weeks in duration, making the traditional notion of mobilization appear to be as archaic and obsolete as the forces and weapons that had been in the past, mobilized.

This study is intended to advance the concept that mobilization is an important component of strategic nuclear conflict, and, we will argue, is likely to be the prototype of any U.S.-Soviet nuclear conflict should such a conflict occur. The concept can be most simply characterized from the perspective of the following simple generalized scenario: During a period of intense political crisis between the U.S. and the Soviet Union, both sides fear that a nuclear war may actually occur. However, neither side is willing to risk the consequences of a nuclear war with the existing levels of forces and defenses (military and civilian). As a consequence, each of the parties attempts to develop on a frantic basis, a very large-scale effective nuclear offense and defense capability which is associated with genuine fears about the possibility of a general war. The period of mobilization during and after an intense political crisis characterizes what we describe as "mobilization warfare." It is warfare in the sense of an intense and bitter competition of an accelerated arms race, but without the certainty that direct military action will occur. A plausible outcome of this scenario is that the side which mobilizes most effectively within a relatively brief period of time (say six months to two years) can achieve a dominant position capable of inhibiting the diplomatic efforts of the other.

The notion of "mobilization warfare" is not restricted only to strategic nuclear warfare. It is also applicable, for example, to a U.S.-Soviet struggle in Europe in which an intense political crisis raises the specter of an outbreak of conventional warfare between the two nations without the expectation that such a conflict would lead to a strategic or tactical nuclear exchange.

Perhaps the closest parallel to mobilization warfare during the nuclear era arose as a consequence of the Korean war. The ominous character of Soviet foreign policy following World War II culminated in the Soviet sponsored attack of North Korean forces against the Republic of Korea. The direction in Soviet foreign policy after World War II was not offset by any rebuilding of U.S. military power which had been rapidly dismantled after the end of World War II. However, when the Soviets authorized the attack on Korea, the change in U.S. attitudes regarding preparedness for a U.S.-Soviet strategic nuclear contingency was electric. One measure of the character of this concern, a measure characteristic of a serious mobilization, was the decision of the Congress to increase annual defense expenditures from $16 to the $60 billion authorized after the outbreak of the Korean war. This vast increase in authorized expenditure made possible a set of strategic programs that were simply not feasible within the prior U.S. defense budget. The new authorization made possible the B–52, the B–47, the Polaris Program, and Atlas Program and a host of related technological initiatives whose consequences are still influencing the shape of the U.S. strategic program today. It also developed a reasonable (for the time) civil defense program designed to move the more vulnerable portions of the home population rapidly to safer areas. As a consequence of this enormous build-up of strategic nuclear capability arising out of the concern over a possible U.S.-Soviet nuclear conflict in the early 1950s, the United States achieved for more than a decade a stark nuclear superiority over the Soviets. This superiority was so vast that in retrospect it appears clear that the Soviets were almost totally deterred from attempts to exert military power in support of their diplomatic objectives throughout the late 1950s and early 1960s.

In the early 1950s the Soviets also attempted to develop a larger strategic program, but were much less successful than the United States. This form of mobilization warfare, we argue, is more likely to become a "standard" mode of nuclear conflict with the Soviet Union than the commonly anticipated mode, namely a large-scale exchange of nuclear weapons.

Perhaps the most significant difference between traditional mobilization concepts and the concept of "mobilization warfare" that is the focus of this paper is that in a modern mobilization, the adequacy of a period of mobilization may be "tested" only in the sense that it can affect the perceptions of an opponent without

a shot being exchanged. Moreover, the period of mobilization in the modern era might be considerably more compressed and complicated than any which we have experienced in this century. In a very practical sense, the mobilization of Germany and the allied powers before the first World War was a traditional process which extended over a period of many years, although the most intense efforts took place after the initiation of the conflict. Similarly, the German and Japanese pre-war mobilization of their forces occurred over many years. In both cases, a large-scale and protracted conflict followed. Under modern conditions, a nuclear conflict between major powers is likely to be short compared to previous conflicts or to any period of mobilization.

The concept of mobilization warfare in a nuclear era implies relatively short reaction times with the ability to deploy major offensive as well as active and passive defensive systems which may be extremely costly and complex by any prior standards. Under such circumstances, it is entirely plausible that the U.S. strategic budget alone could constitute an expenditure of several hundreds of billions of dollars per year. Expenditures at such huge levels make possible a very wide range of military and non-military defense systems that could not be seriously considered with recent strategic budgets—less than $10 billion.

For example, potentially high grade missile defense systems employing lasers, particle beam technology and other advanced concepts for boost phase, mid-course, and terminal interception could, in principle, be procured under conditions of "mobilization warfare." The crucial determinants for acquiring such a capability lies in the prior research and development program and in proper institutional orientation toward a mobilization potential. The requirements of a "mobilization base" to support the notion of mobilization warfare is sufficiently different from the objectives of existing research and development needed to support current and near-term defense requirements that expenditures for a mobilization base should be partitioned from other R&D expenditures. The primary function of a mobilization base is to facilitate the shortening of lead times to procure highly effective strategic forces, active defenses, and civilian protection, should a decision to procure such a capability be made in a context that requires such a build-up be completed in an extraordinarily short period of time (short, that is, by the standards of recent experience). Under some circumstances, it is sufficient simply to have "paper plans" say, for the conversion of designated industrial potential from civilian to military uses. In other cases, where the requirements are more critical, and less easily adaptable to short-term changes, some limited development or prototyping may be necessary. In still other cases, particularly where the function is highly complex and likely to involve large numbers of both civilian and military personnel, such as an ABM or civil defense system, it may be necessary to conduct a limited deployment or field testing, and to develop the professional cadres who could support a vast expansion if and when circumstances require such expansion. The decision as to what elements of a potential U.S. strategic posture should be most extensively or rapidly developed would depend upon the contribution such efforts would make to reducing the lead times necessary to deploy the capability during a period of intense mobilization. The United States already possesses a substantial infrastructure for the rapid short-term expansion of U.S. strategic forces. With relatively modest expenditures, it should be possible to dramatically improve the ability of the United States to mobilize rapidly during an appropriate crisis to increase strategic nuclear forces, its active and passive defenses, and its general purpose forces without the protracted lead times that we have tended to become accustomed to over the past two decades.

2. A baseline mobilization warfare scenario

The implausibility of a U.S.-Soviet strategic nuclear exchange in recent politico-military circumstances has tended to obscure the fact that there are numerous possibilities for a major clash of interests between the superpowers; and consequently, for escalation.

The scenario proposed here arises out of the Achilles' heel of the Soviet Union, the behavior of their East European satellites, in this case, East Germany. Internal dissension develops beyond the control of the local and Soviet political and military leadership in East Germany to the point where large-scale border crossing into West Germany by deserting elements of East German armed forces involve the NATO nations. Unlike the standard escalation scenario where such events lead ultimately to a U.S.-Soviet nuclear exchange, the potential escalation, itself, becomes a force for restraint.

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TYPICAL STRATEGIC MOBILIZATION SCENARIOS

Of the four scenarios given below, the first two are history, the third used to be the great fear of NATO, and the fourth is probably the great fear of the Warsaw Pact.

1. The "phony war," 1940 (5 months):

(a) Pre-crisis arms competition (UK, France, Germany and the U.S.S.R.).

(b) A major series of political-military crisis—
Militarization of the Rhineland (1936);
Anschluss (Austria) (1938);
Sudeten crisis (1938–39);
War in Poland (1939).

(c) De-escalation and negotiation (antagonists began a rapid buildup fearing a resumption of full scale conflict).

2. Korea (1950–53):

(a) Pre-war politico-military crises—
Soviet invasion of Iran (1946);
Soviet takeover of East European nations (1945–48);
Berlin blockade (1948);
Soviet intervention in Turkey and Greece;
Soviet military buildup, post WW-II.

(b) Major turnabout in U.S. policy—
Factor of four increase in defense expenditures in 18 months;
Massive emphasis on strategic preparedness, especially active defense.

3. Successful Soviet attack on W. Berlin and subsequent de-escalation.

4. Uprising in East Germany gets out of control and escalates.

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CHARACTERISTICS OF A SPECIAL MOBILIZATION SCENARIO: A FORMAL DECLARATION OF WAR BY THE U.S.

1. The declaration would have solemn and especially great significance for our enemies, allies, and neutrals.

2. The information transferred would have:

(a) Unambiguous factual content of great importance;
(b) Undeniable implications and symbolism;
(c) Highly uncertain interpretations or implications.

3. Its existence would preempt "ordinary" crisis negotiation and deny the stability of any recent *fait accompli*.

4. In some extreme crises it could be temporizing—a declaration is not a spasm response—and lead to deescalation of actual fighting.

5. But it implies a rapid response to any increased use of force.

6. It tends to force a decision by allies to cooperate actively.

7. It would justify many peripheral actions (blockades, interdiction, property confiscation, internment of hostile aliens, etc.).

8. It would tend to unify the national response—and increase defense spending enormously through mobilization.

9. It would convey the unambiguous message that a *formal* peace treaty will be required to settle all the important issues.

ROLE OF RESEARCH FOR MOBILIZING ACTIVE DEFENSES

1. Missile defense probably would be the most important and expensive effort.

2. Lead-time reduction becomes extremely important.

3. A program is required to facilitate rapid massive procurement of mutually reinforcing systems—
Boost phase interception;
Mid course interception;
Terminal interception.

4. A capability may soon be needed to support a war in space.

5. A capability is required for integration into other—high priority strategic mobilization programs—
Air defense;
Civil defense.

Major research objective: design systems which are highly effective, mutually supporting and which can be rapidly deployed at high levels of expenditure.

Appendix I

Paul Henry Nitze

In the spring of 1969, Paul Henry Nitze was appointed the representative of the Secretary of Defense to the United States Delegation to the Strategic Arms Limitation Talks with the Soviet Union; a position he held until June 1974, at which time he resigned.

Mr. Nitze resigned from his duties as Deputy Secretary of Defense on January 20, 1969, a position he had held since July 1, 1967, succeeding Cyrus R. Vance.

Mr. Nitze was serving as 57th Secretary of the Navy when he was nominated by former President Lyndon B. Johnson on June 10, 1967, to become Deputy Secretary of Defense. He was confirmed by the United States Senate on June 29, 1967.

The late President John F. Kennedy nominated Mr. Nitze to be Secretary of the Navy on October 14, 1963. At that time he was serving as Assistant Secretary of Defense (International Security Affairs), having assumed that position on January 29, 1961. He began his duties as Secretary of the Navy on November 29, 1963.

Graduated "cum laude" in 1928 from Harvard University, Mr. Nitze subsequently joined the New York investment banking firm of Dillon Read and Company. In 1941, he left his position as Vice President of that firm to become financial director of the Office of the Coordinator of Inter-American Affairs.

From 1942–1943, he was Chief of the Metals and Minerals Branch of the Board of Economic Warfare, until named as Director of Foreign Procurement and Development for the Foreign Economic Administration.

During the period 1944–1946, Mr. Nitze was Vice Chairman of the United States Strategic Bombing Survey. He was awarded the Medal of Merit by President Truman for service to the nation in this capacity.

For the next seven years, he served with the Department of State, beginning in the position of Deputy Director of the Office of International Trade Policy. In 1948, he was named Deputy to the Assistant Secretary of State for Economic Affairs. In August, 1949, he became Deputy Director of the State Department's Policy Planning Staff, and Director the following year.

Mr. Nitze left the federal government in 1953 to become President of the Foreign Service Educational Foundation in Washington, D.C., a position he held until January 1961.

Mr. Nitze is Chairman of the Advisory Council of The Johns Hopkins School of Advanced International Studies in Washington, D.C., and also serves on the Board of Trustees of the University. He holds memberships on the Board of Directors of Schroders, Inc., in New York, and Schroders, Ltd., in London, The American Security and Trust Company of Washington, D.C., Northwestern Mutual Life Mortgage and Realty Investors of Milwaukee, Wisconsin, and is Chairman of the Board of the Aspen Skiing Corporation.

Herman Kahn

Herman Kahn was born in Bayonne, New Jersey, in 1922. He received a B.A. from UCLA in 1945 and an M.S. in physics from the California Institute of Technology in 1948. He was associated with the Rand Corporation before becoming in 1961 the principal founder and director of the Hudson Institute, a research organization studying public policy issues, with headquarters in Croton-on-Hudson, N.Y. His international reputation as a strategic warfare analyst or, as the *New Republic* put it, one of "the prophets of strategic reality," is based on his work at the Institute and on his books: *On Thermonuclear War* (1960), *Thinking about the Unthinkable* (1962), *On Escalation* (1965 and, revised Pelican

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STATEMENT OF E. P. WIGNER [1] FOR THE JOINT COMMITTEE ON DEFENSE PRODUCTION

[1] Dr. Wigner is a Nobel Laureate and an emeritus professor of physics at Princeton University and has long been associated with civil defense issues. He edited a 1968 study *Who Speaks for Civil Defense?*

THE EFFECTIVENESS OF CIVIL DEFENSE

This writer became convinced of the possible effectiveness of civil defense measures when he served as a member of the General Advisory Committee to the U.S. Atomic Energy Commission.

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Are the U.S.S.R. and China the only countries with elaborate and well developed civil defense systems? No—most of the peace-loving countries also have such systems, based on blast shelters, and their yearly expenditures per person on such defense is about 15 times greater than ours. This has been, so far, about 40¢ per person a year. Incidentally, the Swiss civil defense repeats our President Kennedy's message: (Civil defense) "is insurance we trust, will never be needed"—its greatest accomplishment is, according to the Swiss, that it will *not* have to be used, that it will divert the aggressive instincts of possible opponents.

It is easy to conclude that an effective civil defense is not only desirable, it is also possible.

IS CIVIL DEFENSE NECESSARY?

What is the principal danger that threatens us in the present absence of an effective civil defense? It is the possibility of the U.S.S.R. evacuating its cities, dispersing their population, and then making demands on us, under the threat of a nuclear attack, approximating those made by Hitler or Czechoslovakia which led to the Munich pact. This left Czechoslovakia essentially defenseless.

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THE ARGUMENTS AGAINST CIVIL DEFENSE

The argument which we heard after the U.S.S.R. civil defense efforts became generally apparent was that our installation of protection for our people would only induce the U.S.S.R. to augment its aggressive capability. We now know that such augmentation took place even though we did not organize a vigorous civil defense effort. One of the two arguments we now hear, the civil defense is too expensive, seems almost ridiculous. If Switzerland, Sweden, etc., *even China*, can afford the more costly, the blast shelter method, we with the highest per capita national wealth, can also surely afford the defense of our people. The other argument, in the words of one of the most learned opponents of civil defense, S. Drell, is that it would lead to an "escalation of the apprehension from the mood of today, vis-a-vis the dangers of a nuclear exchange between the U.S. and the Soviet Union." Should the apprehension of the danger not be greater now, where we have no effective defense, than it would be when we have such defense? Or is it proposed that we should lull the common people into ignorance of the true situation? It is remarkable also that the U.S.S.R. is not criticised for fostering the "apprehension" of its own people. One must conclude that the varying arguments against civil defense have little validity.

A FEW PROPOSALS RELATED TO OUR DEFENSE

The first change I would advocate is to stop maintaining that a nuclear war would be the end of mankind. Such a statement may give the impression to an opponent that he can achieve anything by threatening with a nuclear war. After all, he would argue, the opponent (that is us) will make any sacrifice to avoid the "end of mankind". Hence, if he is threatened with extinction he will give in, particularly if the threat comes from a party which does not believe that the war precipitated by him will lead to the "end of mankind". Instead of such a blatantly incorrect statement, it would be better to subscribe to Chuykov's doctrine that "knowledge and the skillful use of modern protective measures" will make it possible to provide effective protection. At least, we could adhere to Kissinger's earlier (1957) statement: "While it (civil defense) cannot avert the traumatic effect of vast physical destruction, its efficient operation may make the difference between the survival of a society and its collapse."

The second measure which I consider to be urgent is to establish better contact with the people at large. This makes it desirable for DCPA to expand its staff by the employment of people who can establish a contact with the population at large, who can speak and write the truth convincingly. One of the functions of these advisors would be to help the high schools to give instruction on the nature of nuclear explosions and the defense against the effects of these. This is a subject which is foreign to most present high school teachers, and the advisor could and should help them to acquire the necessary knowledge. After all, the Federal Government now intends to support the local schools and can well suggest that these contribute to the protection of the country. The high school instruction on civil defense—obligatory in the U.S.S.R.—would be very useful since, after all, we learn best when we are young and we learn most non-elementary facts from our teachers. But even more generally, the establishment of a close contact between those who protect our freedom, and those whose freedom is protected, would be very desirable; and acquainting people at large with the methods and effectiveness of civil defense would provide an avenue toward this goal. It may not be easy to find people who know about the methods and effectiveness of civil defense and who are also able and interested in communicating this and much other knowledge to the people at large, but every effort should be made to find such people and support them.

The last suggestion I wish to make is that the DCPA budget should certainly not be cut. It should steadily be increased until, in a few years, it reaches the per capita level of other peace-loving and non-expansionist countries, such as Switzerland, Holland, Sweden, etc. For reasons given in the rest of my statement, this would be of decisive importance for maintaining a valid, widely endorsed, and vigorous defense effort for our country—and it would support all freedom-directed nations. Their independence does depend to a certain degree on our strength and our ability to stand up for them. The examples of Hungary, Czechoslovakia, Poland—to mention only a few—show that such independence does not come freely.

Let me end on a bit more hopeful tone which is, however, as sincere as was the rest of my statement. This is the hope that an effective civil defense may not only protect our country and our freedoms, but it may

also lead to a more true peace than the present one, which is based on the fear of destruction. I hope such a peace in which no rulers are tempted to increase their domains will come into being!

Statement of Gerard C. Smith [1]

I propose to discuss this morning some of the arms control implications of Vladivostok as well as certain related aspects of the current Defense budget submission.

I. THE VLADIVOSTOK ACCORD

At the start let me say that I put forward these ideas tentatively, not categorically. I question that anyone can speak with certainty about the slippery issues surrounding strategic arms and their control. I admit to a bias in favor of a very strong defense but I believe that arms control can also advance the security of the United States and the world whether or not there is some relaxation of tensions between the U.S. and the U.S.S.R.

The Vladivostok accord should not be judged in and of itself—but in connection with the limit on defensive systems (ABMs) agreed upon in 1972 and other American-Soviet agreements relating to arms control. It may help in judging the significance of Vladivostok to see that accord as part of a process that has been going on for more than five years. The general strategic dialog of the 1960s led to the specific SALT exchanges of 1969–72 at Helsinki, Vienna, Washington, and Moscow. Gradually the two sides developed somewhat better understanding of each other's strategic preoccupations. Concerns about accidental or miscalculated nuclear hostilities led to the first two SALT agreements in 1971—on measures to reduce the risk of outbreak of nuclear war and on measures to improve the Washington-Moscow direct communication link or "Hot Line." In 1972 there was the major breakthrough, the treaty limiting ABMs to two sites apiece, accompanied by the interim agreement to freeze offensive launches at the approximate levels of 1972. These were followed in 1973 by the Nixon-Brezhnev agreed principles for offensive arms limitation and in 1974 the ABM Treaty levels were reduced to one site apiece. At year's end the Vladivostok accord foreshadowed limitations on offensive systems which although of relatively short duration may be considered as a counterpart of the ABM Treaty. In judging this latest agreement one should consider the cumulative effect of the entire SALT process which hopefully can be considered as a preparatory stage for the natural next steps—reduction in offensive force levels which the sides are now committed to negotiate and some limitation on improvements in weapons characteristics. A total ban on ABM systems should also be reconsidered.

I would not favor interrupting the current Geneva negotiations by introducing a proposal for reductions. I do not believe that reductions are negotiable now. The Soviet position since 1968 has called for first a limitation and subsequently for reductions. When and if

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[1] Mr. Smith is the former Director of the U.S. Arms Control and Disarmament Agency and chief U.S. representative in SALT I. He is now in private practice with the law firm of Wilmer, Cutler, and Pickering. His statement submitted to the Joint Committee was originally delivered to the Senate Foreign Relations Committee in April 1975.

(Gross exaggerations, assuming Nevada desert type terrain with no thermal shadows by city skylines, no duck and cover, no clothing and fraudulent blast effects data which ignores Hiroshima's evidence)

APPENDIX III

U.S. CIVILIAN NUCLEAR FATALITY ESTIMATES [1] FOR VARIOUS COUNTERFORCE ATTACK SCENARIOS

Type of attack	Assumptions	Estimated fatalities
Comprehensive attack:		
Case 1, 60 percent destruction of military targets.	1 optimum height of burst and 1 surface burst warhead per each of 1,054 ICBM silos; pattern attack of SAC bases: unspecified attack on 2 SSBN support bases; good shelter posture.	3, 200, 000
Case 2, 60 percent destruction of military targets.	2 optimum height of burst warheads per each of 1,054 ICBM silos; no pattern attack of SAC bases; unspecified attack on 2 SSBN support bases; poor shelter posture.	6, 700, 000
Case 3, 57–60 percent destruction of military targets.	2 surface burst warheads per each of 1,054 ICBM silos; pattern attack of SAC bases; unspecified attack on 2 SSBN support bases; very poor shelter posture.	16, 300, 000
ICBM only attack:		
Case 1	2 550 kt optimum height of burst warheads per each of 1,054 ICBM silos.	[2] 4, 000, 000
Case 2, 42 percent silo destruction.	1 550 kt surface burst and 1 550 kt optimum height of burst warhead per each of 1,054 ICBM silos.	5, 600, 000
Case 3, 80 percent silo destruction.	1 3 Mt surface burst and 1 3 Mt optimum height of burst warhead per each of 1,054 ICBM silos.	18, 300, 000
Case 4	2 3 Mt surface burst warheads per each of 1,054 ICBM silos	[3] 20, 000, 000
Airlift attack: [4]		
Case 1	1 200 kt cruise missile warhead per each of 5 U.S. heavy airlift bases (Dover AFB, Del.; McGuire AFB, N.J.; Travis AFB, Calif.; Charleston AFB, S.C.; and McChord AFB, Wash.)	70, 000
Case 2	1 1.2 Mt SLBM per each of 5 U.S. heavy airlift bases	210, 000
Case 3	1 1.2 Mt SLBM per each of 5 U.S. heavy airlift bases uses offset targeting.	135, 000

[1] Department of Defense estimates as reported to the Senate Foreign Relations Committee, July 11, 1975, and published in "Analyses of Effects of Limited Nuclear War," pp. 12–24. Note that figures are fatalities only and not casualties and that attacks are restricted to military facilities (counterforce) rather than populated areas (countervalue). Shelter posture is a function of degree of hardening and the willingness of the population to use shelters.

[2] Under.

[3] Circa.

[4] Assumes allied victories in a European war supported by U.S. military airlift provide incentives for destruction of major American airlift centers.

Survival of the Relocated Population of the U.S. After a Nuclear Attack

FINAL REPORT • JUNE 1976 ORNL-5041

by

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for

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ADA026362

SURVIVAL OF THE RELOCATED POPULATION OF THE U.S. AFTER A NUCLEAR ATTACK

C. M. Haaland, C. V. Chester, and E. P. Wigner

ABSTRACT

The feasibility of continued survival after a hypothetical nuclear attack is evaluated for people relocated from high-risk areas during the crisis period before the attack. The attack consists of 6559 MT, of which 5951 MT are ground bursts, on military, industrial, and urban targets. Relocated people are assumed to be adequately protected from fallout radiation by shelters of various kinds. The major problems in the postattack situation will be the control of exposure to fallout radiation, and prevention of severe food shortages to several tens of millions of people. A reserve of several million additional dosimeters is recommended to provide control of radiation exposure. Written instructions should be provided with each on their use and the evaluation of the hazard. Adequate food reserve exists in the U.S. in the form of grain stocks, but a vigorous shipping program would have to be initiated within two or three weeks after the attack to avoid large scale starvation in some areas. If the attack occurred in June when crops on the average are the most vulnerable to fallout radiation, the crop yield could be reduced by about one-third to one-half, and the effects on crops of possible increased ultraviolet radiation resulting from ozone layer depletion by nuclear detonations may further increase the loss. About 80% of the U.S. crude refining capacity and nearly all oil pipelines would be either destroyed or inoperative during the first several weeks after an attack. However, a few billion gallons of diesel fuel and gasoline would survive in tank storage throughout the country, more than enough for trains and trucks to accomplish the grain shipments required for survival. Results of a computer program to minimize the ton-miles of shipments of grain between Business Economic Areas (BEAs) indicate that less than 2% of the 1970 rail shipping capacity, or less than 6% of the 1970 truck shipping capacity would be adequate to carry out the necessary grain shipments. The continuity of a strong federal government throughout the attack and postattack period is essential to coordinate the wide-scale interstate survival activities.

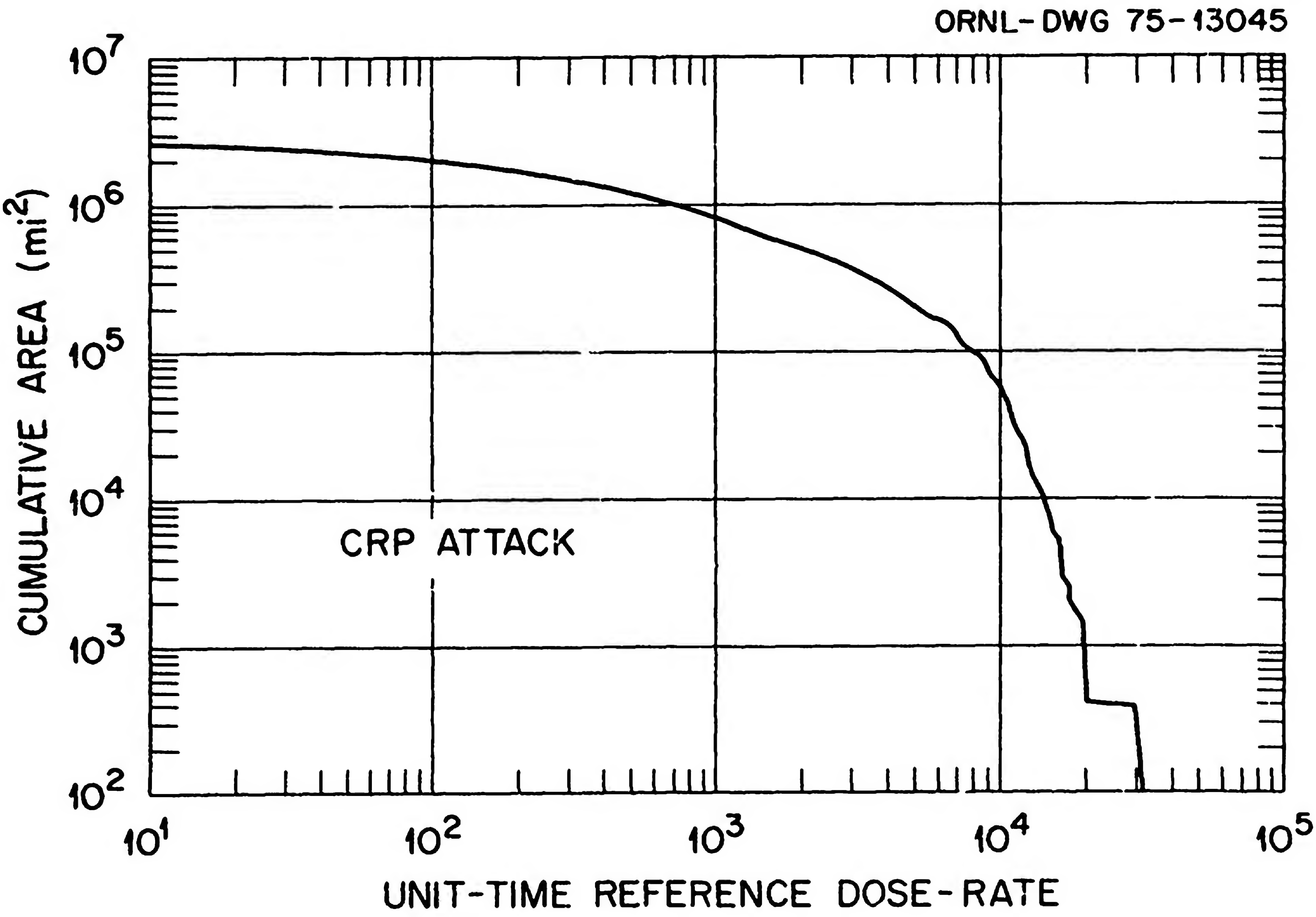

Fig. 4.2 Area of U.S. as a Function of Unit-Time Reference Dose Rate.

THE WHITE HOUSE

WASHINGTON

#76

~~TOP SECRET/SENSITIVE~~

July 25, 1980

Presidential Directive/NSC-59

TO: The Vice President
The Secretary of Defense

ALSO: The Assistant to the President for National Security Affairs
The Chairman, Joint Chiefs of Staff

SUBJECT: Nuclear Weapons Employment Policy (C)

In PD-18, I directed a follow-on study of our targeting policy for nuclear forces. I have reviewed the results and considered their implications for maintaining deterrence in the present decade, particularly in light of the growing Soviet strategic weapons arsenal and its capabilities. (S)

The most fundamental objective of our strategic policy remains nuclear deterrence. I reaffirm the directive of PD-18 to that effect. The purpose of this directive is to outline policies and actions in the nuclear force employment field to secure that continuing objective. (S)

Our strategic nuclear forces must be able to deter nuclear attacks not only on our own country but also on our forces overseas, as well as on our friends and allies, and to contribute to deterrence of non-nuclear attacks. To continue to deter in an era of strategic nuclear equivalence, it is necessary to have nuclear (as well as conventional) forces such that in considering aggression against our interests any adversary would recognize that no plausible outcome would represent a victory on any plausible definition of victory. To this end and so as to preserve the possibility of bargaining effectively to terminate the war on acceptable terms that are as favorable as practical, if deterrence fails initially, we must be capable of fighting successfully so that the adversary would not achieve his war aims and would suffer costs that are unacceptable, or in any event greater than his gains, from having initiated an attack. (C)

~~TOP SECRET/SENSITIVE~~
Review on May 15, 2000
Reason for Extension: NSC 1.13(e)

Downgraded Per per 6/12/09 NSC ltr,
Case 2008-085

DECLASSIFIED
Authority 6/12/09 LTR, 08-085
NARA [signature] Date 7/24/12

The employment of nuclear forces must be effectively related to operations of our general purpose forces. Our doctrines for the use of forces in nuclear conflict must insure that we can pursue specific policy objectives selected by the National Command Authorities at that time, from general guidelines established in advance. (S)

These requirements form the broad outline of our evolving countervailing strategy. To meet these requirements, improvements should be made to our forces, their supporting C3 and intelligence, and their employment plans and planning apparatus, to achieve a high degree of flexibility, enduring survivability, and adequate performance in the face of enemy actions. The following principles and goals should guide your efforts in making these improvements. (S)

Pre-planned options. The Single Integrated Operational Plan will provide pre-planned targeting for strikes against the Soviet Union, its allies and its forces. It should provide for retaliatory strikes that will be effective, even if the Soviets attack first, without warning, and in a manner designed to reduce our capability as much as possible. It will be developed with flexible sub-options that will permit, to the extent that survival of C3 allows, sequential selection of attacks from among a full range of military targets, indistrial targets providing immediate military support, and political control targets, while retaining a survivable and enduring capability that is sufficient to attack a broader set of urban and industrial targets. In addition, to the maximum extent possible, pre-planned options will be provided for selection in response to specific, lesser contingencies (including attacks on Cuba, SRV and North Korea as appropriate). [redacted]

While it will remain our policy not to rely on launching nuclear weapons on warning that an attack has begun, appropriate pre-planning, especially for ICBMs that are vulnerable to a preemptive attack, will be undertaken to provide the President the option of so launching. (TS)

Flexibility. In addition to pre-planned options we need an ability to design nuclear employment plans on short notice in response to the latest and changing circumstances. This capability must be comprehensive enough to allow rapid construction of plans that integrate strategic force employment with theater nuclear force employment and general purpose force employment for achieving theater campaign objectives and other national objectives when pre-planned response options are not judged suitable in the circumstances. (S)

To assure that we can design such plans, our goal should be to have the following capabilities on a continuing basis in peacetime, during crises, and during protracted conflict:

-- Staff capabilities, within all unified and specified commands which have nuclear forces, to develop operational plans on short notice and based on the latest intelligence.

-- Staff capabilities at the seat of Government to support the NCA for coordinating and integrating the nuclear force employment for all commands.

-- Intelligence and target development capabilities which permit damage assessment and acquisition of a broad range of targets, fixed and mobile, on a timely basis for military operations. (S)

Reserve Forces. Pre-planned options should be capable of execution while leaving a substantial force in secure reserve and capable of being withheld for possible subsequent use. The forces designated for the reserve should be the most survivable and enduring strategic systems consistent with the need for a flexible and varied reserve force capable of being effectively employed against a wide target spectrum and withheld if necessary for a prolonged period. The secure reserve force will be increased over the next two years to support a more flexible execution of our countervailing strategy. This will be done according to the Secretary of Defense's guidance. (TS)

Targeting categories. Overall targeting planning appropriate to implement a countervailing strategy will result in a capability to choose to put the major weight of the initial response on military and control targets. Military targets must be selected for the purpose of destroying enemy forces or their ability to carry out military operations. Strategic and theater nuclear forces should to the extent feasible be used in combination with, and in support of, general purpose forces to achieve that objective. (S)

More specifically, the following categories of military targets, with appropriate sub-options for different theaters, should be covered in planning:

-- strategic and theater nuclear forces, including nuclear weapons storage;

-- military command, control, communications, and intelligence capabilities;

-- all other military forces, stationary and mobile;

-- industrial facilities which provide immediate support to military operations during wartime. (TS)

In addition, pre-planned options, capable of relatively prolonged withhold or of prompt execution, should be provided for attacks on the political control system and on general industrial capacity. (TS)

There must be extensive and effective coverage in the pre-planned options of all categories. Methods of attack on particular targets should be chosen to limit collateral damage to urban areas, general

industry and population targets outside these categories, consistent with effectively covering the objective target, and, where appropriate, overall plans should include the option of withholds to limit such collateral damage. (TS)

Command, Control and Communications, and Intelligence. Flexibility in contingency planning and in operations will be highly dependent on our C^3I capabilities, including their ability to acquire targets, assess damage, and survive attack. Strategic stability in an era of essential equivalence depends as much on survivability, endurance and reconstitutability of C^3I capabilities as it does on the size and character of strategic arsenals. (C)

PD/NSC-53 directs that our C^3I programs and our guidance to telecommunications common carriers support the development and maintenance of such capabilities. In addition, PD/NSC-41 directs that we seek greater continuity of government should deterrence fail. Implementation of PD/NSC-53 and PD/NSC-41 must be pursued in parallel with that of this employment directive. (C)

The relationship of acquisition policy to employment policy. Our acquisition programs must be evaluated in terms of their support for the employment policy ordered by this directive. The required flexibility, survivability, endurance, and target destruction capability must be taken into account in developing programs for acquiring nuclear weapons systems, and their supporting C^3I systems, needed to support our countervailing strategy. (S)

Implementation. As new targeting capabilities are developed, and as our operational staffing support change to meet the foregoing directives, they must be reviewed and tested to validate their feasibility and soundness. For that purpose:

-- At least two exercises involving the National Command Authorities should be conducted each year to evaluate our capabilities and our employment doctrines.

-- Continued study and analysis of means to improve and refine our countervailing strategy of general conflict should be conducted by the Department of Defense.

-- The results of these exercises, studies and analysis will provide the bases for modification and any further development of employment and acquisition policy.

-- A report will be rendered to the President at least annually on our employment plans, including, but not limited to, on the size and capability of the reserve forces, the degree of flexibility available,

limiting factors in achieving flexibility, and the status of programs to provide improvements.

-- Any change or new pre-planned options will be submitted to the President for his review and approval, in accordance with current procedures. (TS)

NSDM-242 is superseded by this directive. (U)

Jimmy Carter

NUCLEAR WAR STRATEGY

(Concerning President Carter's 25 July 1980 Presidential Directive PD-59, "Nuclear Weapons Employment Policy")

HEARING

BEFORE THE

COMMITTEE ON FOREIGN RELATIONS
UNITED STATES SENATE

NINETY-SIXTH CONGRESS

SECOND SESSION

ON

PRESIDENTIAL DIRECTIVE 59

SEPTEMBER 16, 1980

(TOP SECRET HEARING HELD ON SEPTEMBER 16, 1980; SANITIZED AND PRINTED ON FEBRUARY 18, 1981)

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APPENDIX

ADMINISTRATION'S RESPONSES TO QUESTIONS SUBMITTED BEFORE THE HEARING

Question 1. What are the basic strategic targeting priorities in PD–59? How do these differ from previous targeting guidance, particularly that contained in NSDM 242?

Answer. PD–59 specifies the development of plans to attack a comprehensive Soviet/Warsaw Pact target system, with the flexibility to employ these plans, should deterrence fail, in a deliberate manner consistent with the needs of the situation and in a way which will deny an aggressor any gain, or would impose costs which clearly exceed his expected gains. This could entail initial retaliation on military and control targets while retaining the capability either to withhold for a relatively prolonged period, or to execute, broad retaliatory attacks on the political control system and on general industrial capacity. These individual target systems, which we feel the Soviet leaders value most, include leadership and control, military forces both nuclear and conventional and the industrial/economic base. Highlights of targeting aspects include an increased number of situation-oriented options, and more flexibility for selectively attacking all categories of targets.

PD–59 requires the option to attack a full range of industrial/economic targets be retained. PD–59 also places more emphasis on how to improve the effectiveness of targeting retaliation against Warsaw Pact leadership and control, nuclear forces, and conventional forces in a wartime situation. In contrast to some pronouncements by the press, the United States has never had a doctrine based simply and solely on reflexive, massive attacks on Soviet cities. Instead, we have always planned both more selectively (options limiting industrial/economic damage) and more comprehensively (a range of military targets in addition to the industrial/economic base). Previous Administrations, going back well into the 1960s, recognized the inadequacy of a strategic doctrine that would give us too narrow a range of options. The fundamental premises of our countervailing strategy are a natural evolution of the conceptual foundations built over the course of a generation. PD–59 is not a new strategic doctrine; it is not a radical departure from past U.S. strategic policy. Our countervailing strategy, as formally stated in PD–59, is in fact, a refinement, a codification of previous statements of our strategic policy. PD–59 takes the same essential strategic doctrine, and restates it more clearly, more cogently, in the light of current conditions and current capabilities.

Question 2. What are the fundamental political and military objectives for strategic targeting in PD–59? Is it envisaged that the United States could, under certain circumstances, conduct limited nuclear war for foreign policy, political or military objectives? Does the PD–59 envision the possibility of U.S. nuclear retaliation for any provocation short of a nuclear attack on the United States or its allies?

Answer. Deterrence remains, as it has been historically, our fundamental strategic objective. The overriding objective of our strategic forces is to deter nuclear war. But deterrence must restrain an adversary from carrying out any of a far wider range of threats than just that of massive attacks of U.S. cities. We seek to deter any adversary from any course of action that could lead to general nuclear war. Our strategic forces also must deter nuclear attacks on smaller sets of targets in the United States or on U.S. military forces overseas, and deter the nuclear coercion of, or attack on, our friends and allies. Our strategic forces, in conjunction with theater conventional and nuclear forces, must also contribute to deterrence of conventional aggression as well. I say "contribute" because we recognize that neither nuclear forces nor the cleverest theory for their employment can eliminate the need for us—and our allies—to provide a capable conventional deterrent.

In our analysis and planning, we are necessarily giving greater attention to how a nuclear war would actually be fought by both sides if deterrence fails. There is no contradiction between this focus on how a war would be fought and what its results would be, and our purpose of insuring continued peace through deterrence. Nor is there a contradiction between this focus and a judgment that escalation of a "limited" to an "all-out" nuclear war is likely. Indeed, this focus helps us achieve deterrence and peace, by insuring that our ability to retaliate is fully credible. We must have forces, contingency plans, and command and control capabilities that will convince the Soviet leadership that no war and no course of aggression by them that led to use of nuclear weapons—on any scale of attack and at any stage of conflict—could lead to victory, however they may define victory.

Operationally, our countervailing strategy requires that our plans and capabilities be structured to put more stress on being able to employ strategic nuclear forces selectively, as well as by all-out retaliation in response to massive attacks on the United States. It is our policy—and we have increasingly the means and the detailed plans to carry out this policy—to ensure that the Soviet leadership knows that if they chose some intermediate level of aggression, we could, by selective, large (but still less than maximum) nuclear attacks, exact an unacceptably high price in the things the Soviet leaders appear to value most—their military forces both nuclear and conventional, their political and military control apparatus, and the industrial capability to sustain a war. In our planning we have not ignored the problem of ending the war, nor would we ignore it in the event of a war. And, of course, we have, and we will keep, a survivable and enduring capability to attack the full range of targets, including the Soviet economic base, if that is the appropriate response to a Soviet strike.

The United States already retains the option of using weapons in a limited way in response to a conventional attack on us or our allies if necessary. However, PD–59 does *not* propose a first strike strategy. We are talking about what we could and (depending on the nature of a Soviet attack) would do in response to a Soviet attack. Nothing in the policy contemplates that nuclear war can be a deliberate instrument of achieving our national security goals because it cannot be. But we cannot afford the risk that the Soviet leadership might entertain the illusion that nuclear war could be an option—or its threat a means of coercion—for them.

Question 3. What alternative targeting strategies were examined in the studies which preceded PD–59? On what grounds were such alternatives rejected? Was the President presented with alternatives to the targeting policy set forth in PD–59?

Answer. Alternative targeting strategies were addressed. The alternative strategies examined were: (a) strengthen existing policy; (b) focus more heavily on denying Soviets a favorable war outcome; (c) add higher confidence capability against some target systems; and (d) rely more heavily on assured destruction.

Under alternative (a) the forces and related C^3I to accomplish this strategy would be given added endurance.

Alternative (b) placed more emphasis on targeting of Soviet (and non Soviet Warsaw Pact) nuclear and conventional forces to assure that they could not expect to achieve a favorable outcome or a victory, however victory might be defined, while retaining an assured destruction capability.

Alternative (c) would require greater capabilities against certain Soviet forces than in alternative (b).

The last alternative, (d), also would avoid the need to make any improvements to the flexibility and endurance of strategic forces and C^3I.

Each of the alternatives was considered in light of: (a) what flexibility in our nuclear posture (i.e., how broad a range of options) is desired; (b) how much endurance do our forces and C^3I require; (c) how much capability is considered necessary; (d) costs of achieving these capabilities.

These considerations were weighed against the ability of each of the alternatives to deter the Soviets, taking into account Soviet attitudes toward concepts of nuclear war and perceptions of our capabilities and will, as well as the perceptions of our friends and allies. In the final analysis, a policy was selected which was judged to be most realistic considering the current relationship between the U.S. and the U.S.S.R., and the world situation, and considering the continued aggressive pursuit by the Soviets of comprehensive improvement in all aspects of military force capabilities, both nuclear and conventional.

A belief in the continuing utility of war as a policy instrument and the need for military superiority fit well into Soviet discussions of victory in a global conflict. It should be noted that Soviet civilian leadership has made statements as to the destructiveness of nuclear war and the need for U.S.-U.S.S.R. arms control measures. At the same time, it is appropriate to take note of high level Soviet statements which tend to point to a somewhat different direction. For instance, the Chief of the Soviet Strategic Missile Forces has observed that:

> The imperialist ideologists are trying to lull the vigilance of the world's people by having recourse to propoganda devices to the effect that there will be no victors in a future nuclear war. These false affirmations contradict the objective laws of history . . . Victory in war, if the imperialists succeed in starting it, will be on the side of world socialism and all progressive mankind. (Marshal of the Soviet Union N. I. Krylov, "The Instructive Lessons of History", *Sovetskaia Rossiia*, August 30, 1969, UNCLASSIFIED).

President (and Marshal of the Soviet Union) Brezhnev is also on record as saying that:

> Let it be known to all that in a clash with any aggressor the Soviet Union will win a victory worthy of our great people, of the homeland of the October Revolution. (L. I. Brezhnev, Speech on the 50th Anniversary of the October Revolution, *Pravda*, November 4, 1967, UNCLASSIFIED).

In addition to such doctrinal presentations, the Soviet leaders make evident through their programs their concerns about the failure of deterrence as well as its maintenance, and their rejection of such concepts as minimum deterrence and assured destruction as all-purpose strategic theories. As Secretary Brown has indicated, what is most troublesome is the heavy emphasis in Soviet military doctrine on the acquisition of war-winning (whatever the duration of the conflict) capabilities, and the coincidence (in one sense or another of the word) between their programs and what have been alleged as the requirements of a deliberate war-winning strategy. This compilation of Soviet sources—which could be added to almost indefinitely—is sufficient to demonstrate that the Ogarkov quotation used in the speech quoted in the question was not an aberration. There are, to be sure, quotations to be found that indicate different views—partly because there are no doubt different views within the Soviet system, more often because they are addressed to different audiences. There is no question that the Soviet leadership understands that nuclear war would be immensely destructive and uncertain; it is to re-inforce that perception—and to add to it the conclusion, found only very infrequently if at all in public statements, that the U.S.S.R. could not fight and win such a war—that the countervailing strategy is directed.

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FOR EXTERNAL PUBLICATION

Radio Moscow in Mandarin to China, Nov. 3, 1978.

"However, the fact is that China's digging deep tunnels can never protect the Chinese masses from nuclear bombing or even protect them from conventional heavy bombs."

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Radio Moscow World Service in English, Nov. 16, 1978

"The U.S. Administration is going to launch a 5-year program of civil defense. - - - The only real safety for the Americans is strengthening friendship with the Soviet Union, not bomb shelters."

FOR INTERNAL PUBLICATION

Moscow *Voyennyye Znaniya* in Russian No. 5, May 1978, p. 33.

"It is appropriate to say that we still meet people who have an incorrect idea about defense possibilities. The significant increase in the devastating force of nuclear weapons compared with conventional means of attack makes some people feel that death is inevitable for all who are in the strike area. However, there is not and can never be a weapon from which there is no defense. With knowledge and the skillful use of contemporary procedures, each person can not only preserve his own life but can also actively work at his enterprise or institution. The only person who suffers is the one who neglects his civil defense studies."